SI Analysis & Measurement as easy as mobile apps

ISD, ADK, X2D2

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Outline

- Can SI tools be made like mobile apps?
- Introduction of AtaiTec SI software
  - Most applications in ~3 clicks.
- In-Situ De-embedding (ISD)
  - Fix causality problems commonly found in other de-embedding tools.
- Advanced Design Kit (ADK)
  - Many mobile-apps-like SI tools in one place: S-param quality, TDR/TDT, eye diagrams, compliance testing, …
- Advanced 2D solver (X2D2)
  - Model and extract DK, DF and roughness.

If it takes more than 5 seconds to do any of these, it is too long…

Fill in DC

Interpolate

Passivity & causality correction

S-param quality

De-embed

Extrapolate

SPICE models

Cascade

TDR & TDT

Combine multiple S-param files

Eye Diagram
(with FFE, CTLE, DFE)

Surface roughness model

Compliance testing

Extract material property

Change reference impedance

Plot [S]

Confucius said…

The mechanic that would perfect his work must first sharpen his tools.

工欲善其事，必先利其器。

To have a good job, find a good boss and good co-workers.

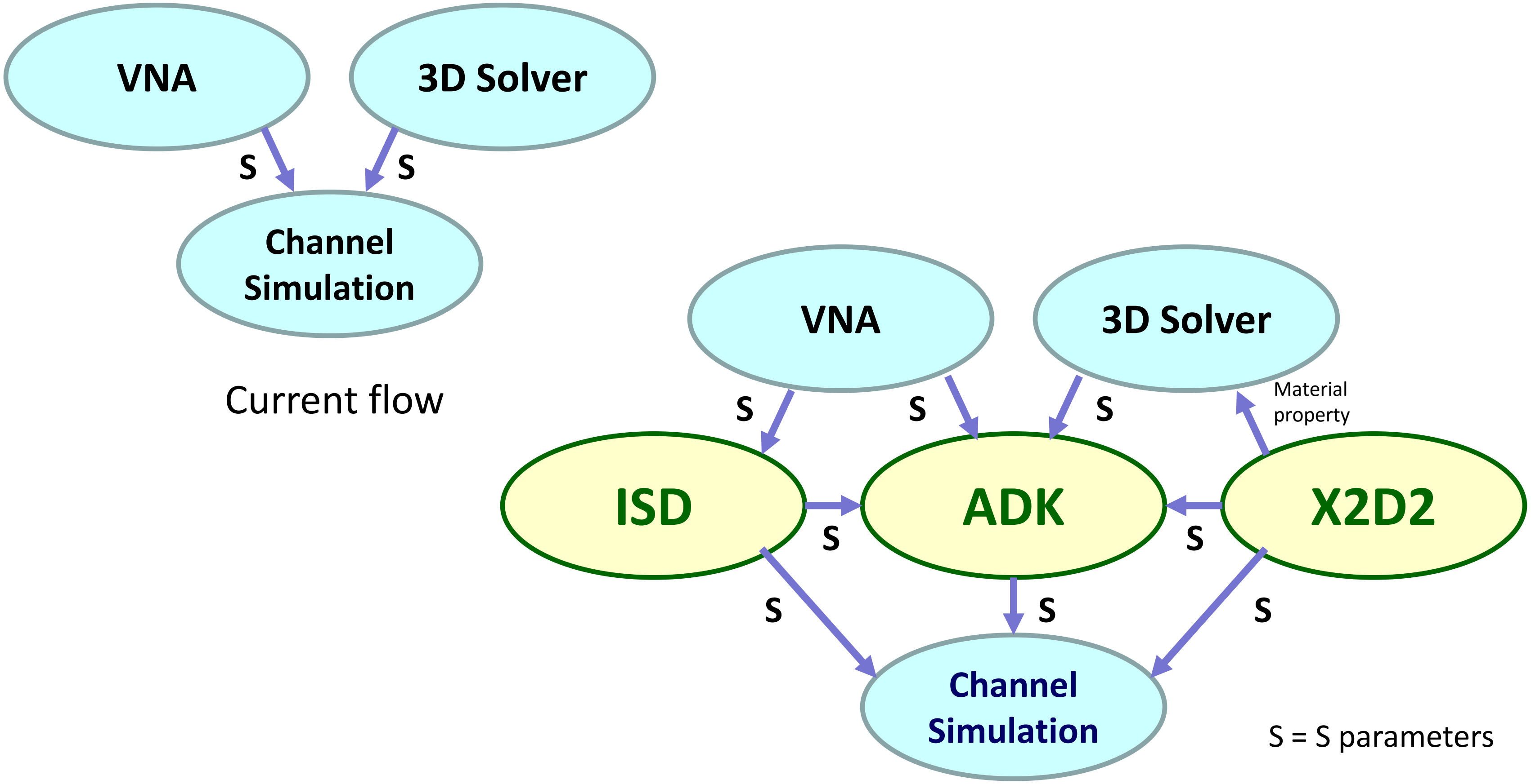
居是邦也，事其大夫之賢者，友其士之仁者。

Confucius

551 BC - 479 BC

“Sharp” tools from AtaiTec

Mobile-apps-like SI software increases productivity



VNA

3D Solver

S

S

Channel Simulation

Current flow

VNA

3D Solver

S

S

S

Material property

ISD

ADK

X2D2

S

S

S

S

S

Channel Simulation

S = S parameters

AtaiTec enhanced flow

AtaiTec SI software

Most applications in ~3 clicks

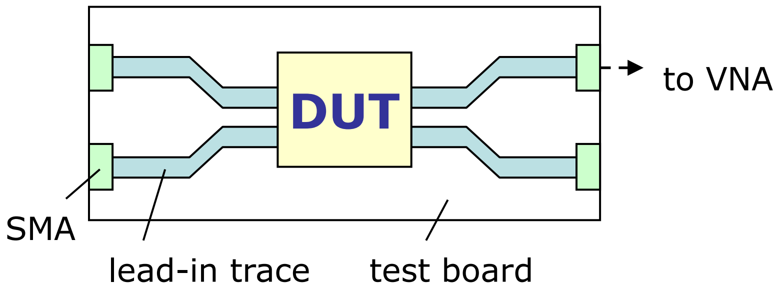
- In-Situ De-Embedding (ISD)
  - A cost-saving alternative to replace TRL calibration.
  - Simple – Only one 2x through test coupon is needed.
  - Save $$$ – Save SMAs, board material, and time.
  - Accurate – Remove fixture crosstalk; causal DUT results.

- Advanced Signal Integrity Design Kits (ADK)
  - TDR/TDT, passivity & causality correction, eye diagrams, S-to-Spice, scope de-embedding and a lot more.
  - Complex SI operations in one mouse click.

- X2D2
  - Accurate 2D solver for modeling causal dielectric and surface roughness.
  - Extract material property with ISD.

In-Situ De-embedding (ISD)

Causal by construction



In Situ De-Embedding

Version 2016.01

Test Coupons

● 2x Thru ○ 1x Open + 1x Short
○ 1x Open ○ 1x Short

Select Touchstone File (2x Thru)

D:\Trace_L1_2xthru.s4p

Insertion loss behavior

● Linear ○ Nonlinear ○ Resonant

DUT with Fixture

Select Touchstone File

D:\Trace_L2_fixtureDUT.s4p

Port sequence

● 1 to N on left; N+1 to 2N on right
○ 1, 3, 5, ... on left; 2, 4, 6, ... on right
○ All ports are on the left side

Optional

Scaling for lead-in flight time: 1
Scaling for lead-in attenuation: 1
Flight time for DUT + lead-ins: ps
Max. frequency to de-embed: GHz

☑ Enforce passivity for test coupons (& fixture)
☐ Convert to differential signals
☐ Active DUT ☑ Plot figures for DUT

Ports to skip

● None ○ Left ○ Right
○ Specified :

Coupling among de-embedding traces

○ None ○ Weak ● Strong

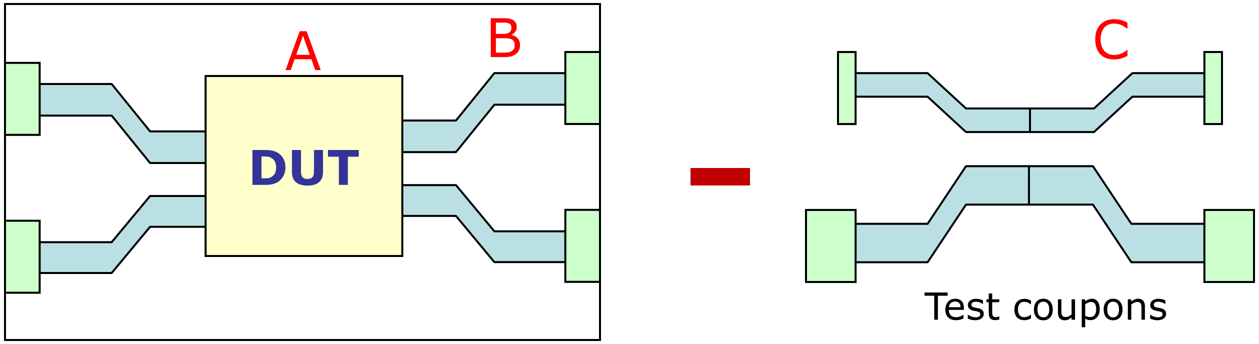
- The goal is to de-embed the fixture effect and extract DUT data.
- ISD uses "2x thru" or "1x open / 1x short" as reference and de-embed fixture's actual impedance through optimization.

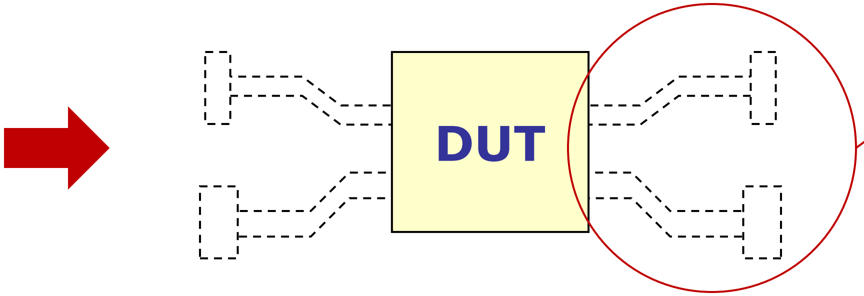
In Situ

- De-embedding is made easy as 1-2-3.
- Save SMAs, board material and time.

Why do most de-embedding tools give causality error

- Most tools use test coupons directly for de-embedding, so difference between actual fixture and test coupons gets piled up into DUT results.





Phantom limbs* due to difference in fiber weave, etching, soldering, …

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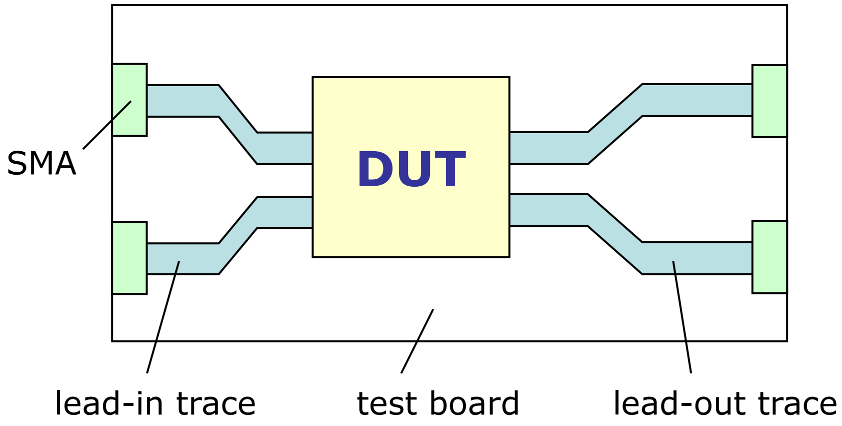
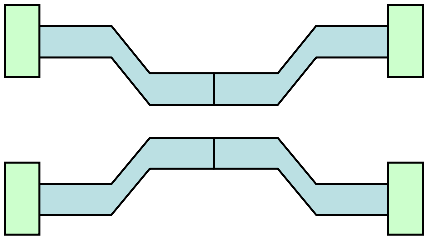
* http://www.edn.com/electronics-blogs/test-voices/4438677/Software-tool-fixes-some-causality-violations by Eric Bogatin

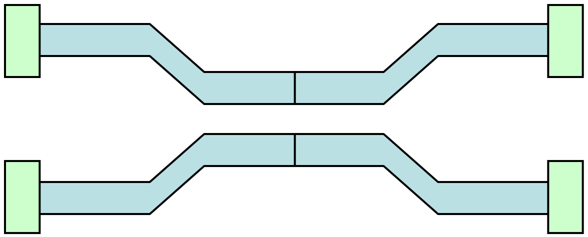
What is “2x thru”

- “2x thru” is 2x lead-ins or lead-outs.





2x thru for lead-ins

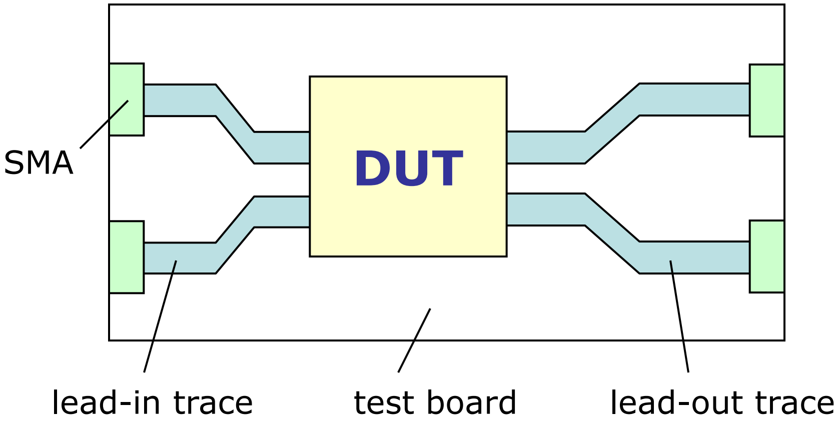


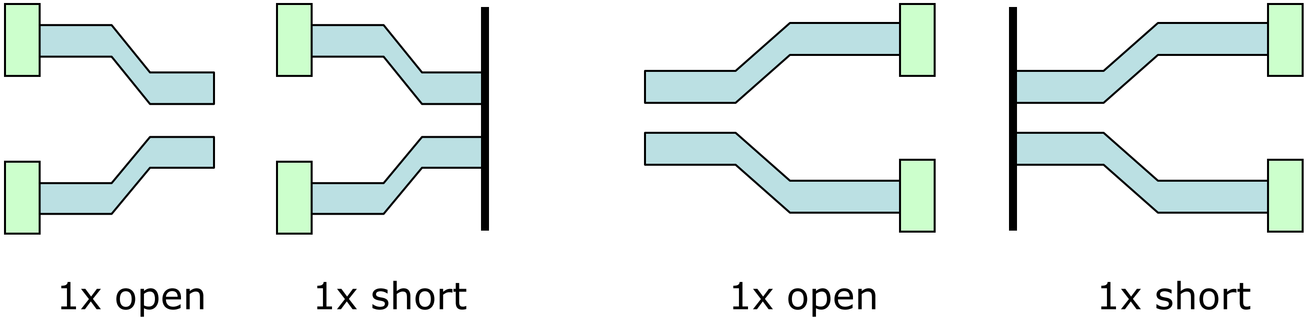
2x thru for lead-outs

2 sets of “2x thru” are required for asymmetric fixture.

What is “1x open / 1x short”

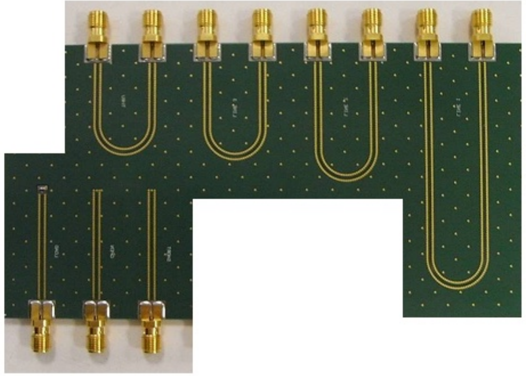
- “1x open / 1x short” is useful when “2x thru” is not possible (e.g., connector vias, package, …).





Why ISD is more accurate and saves $$$

TRL calibration board



- More board space - Multiple test coupons are required.
- Test coupons are used directly for de-embedding.
- All difference between calibration and actual DUT boards gets piled up into DUT results.
- Expensive SMAs, board materials (Roger) and tight-etching-tolerance are required.
  - Impossible to guarantee all SMAs and traces are identical (consider weaves, etching, …)
- Time-consuming manual calibration is required.
  - Reference plane is in front of DUT.

ISD test coupon

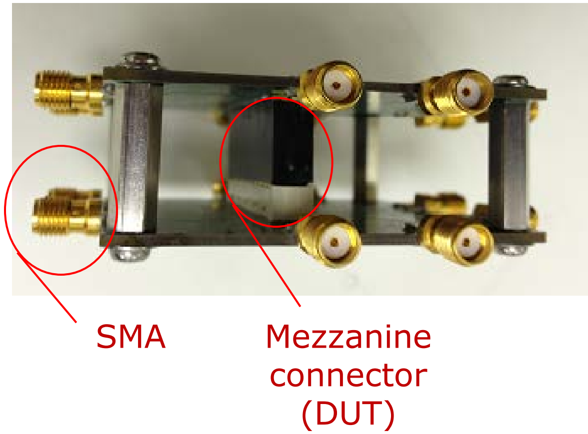
- Only one 2x thru test coupon is needed.
- Test coupon is used only for reference, not for direct de-embedding.
- Actual DUT board impedance is de-embedded.
- Inexpensive SMAs, board materials (FR4) and loose-etching-tolerance can be used.
- ECal can be used for fast SOLT calibration.
  - Reference plane is in front of SMA.
  - De-embedding is made easy as 1-2-3 with only two input files: 2x thru and DUT board (SMA-to-SMA) Touchstone files.
  - More information: Both de-embedding and DUT files are provided as outputs.

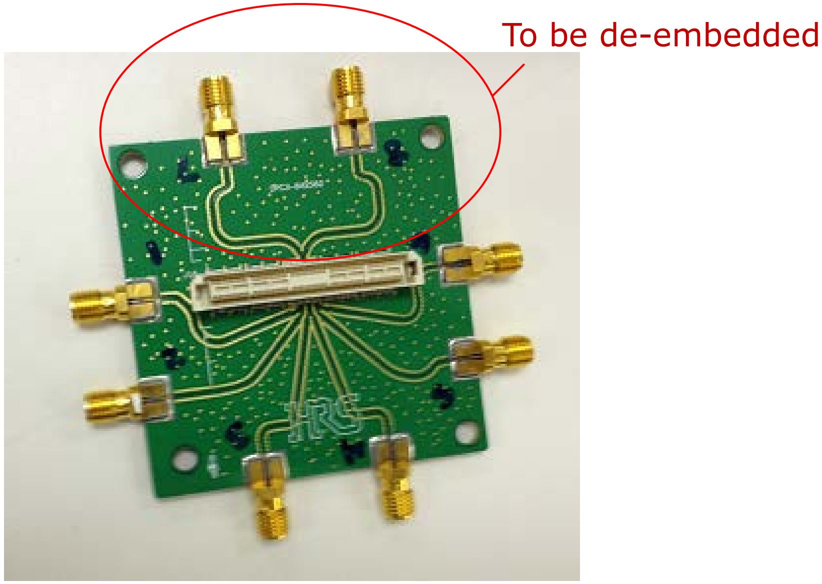
* TRL = Thru-Reflect-Line

Example 1: Mezzanine connector

ISD vs. TRL

- In this example, we will use ISD and TRL to extract a mezzanine connector and compare their results.



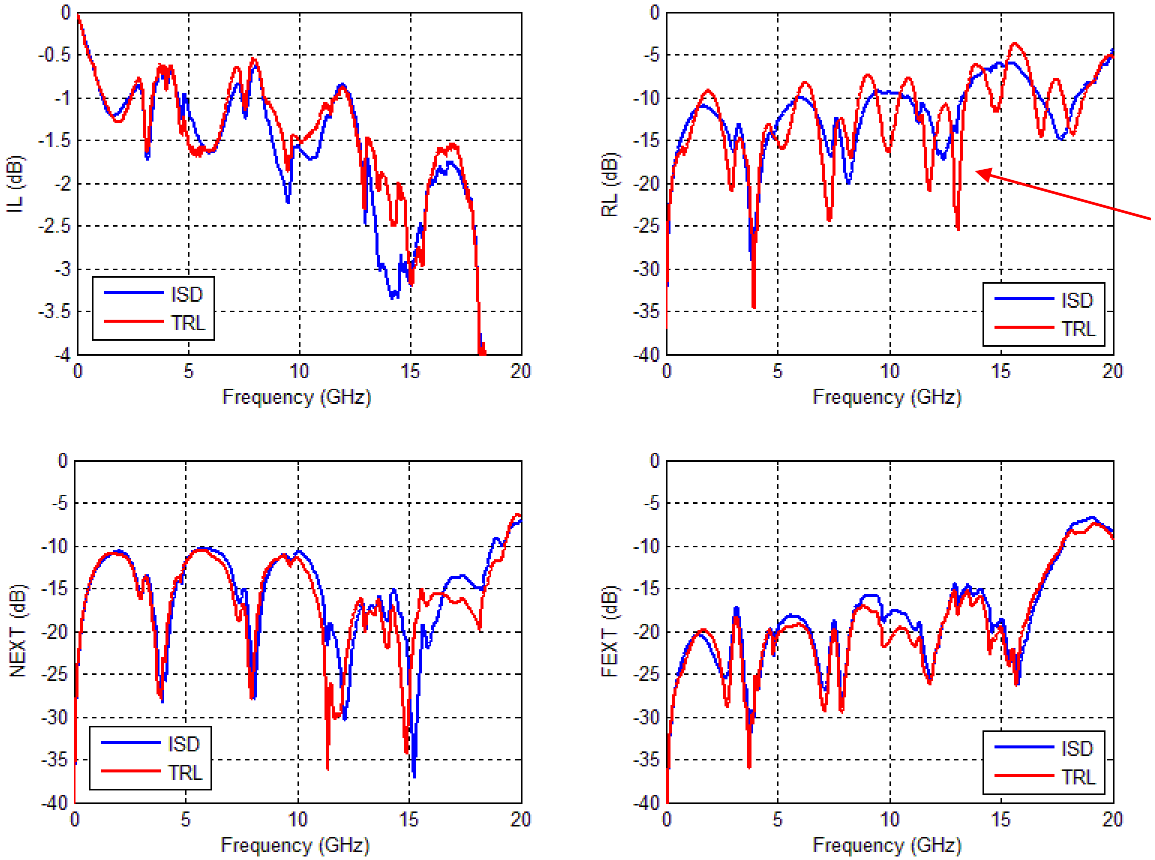


*Courtesy of Hirose Electric

DUT results after ISD and TRL

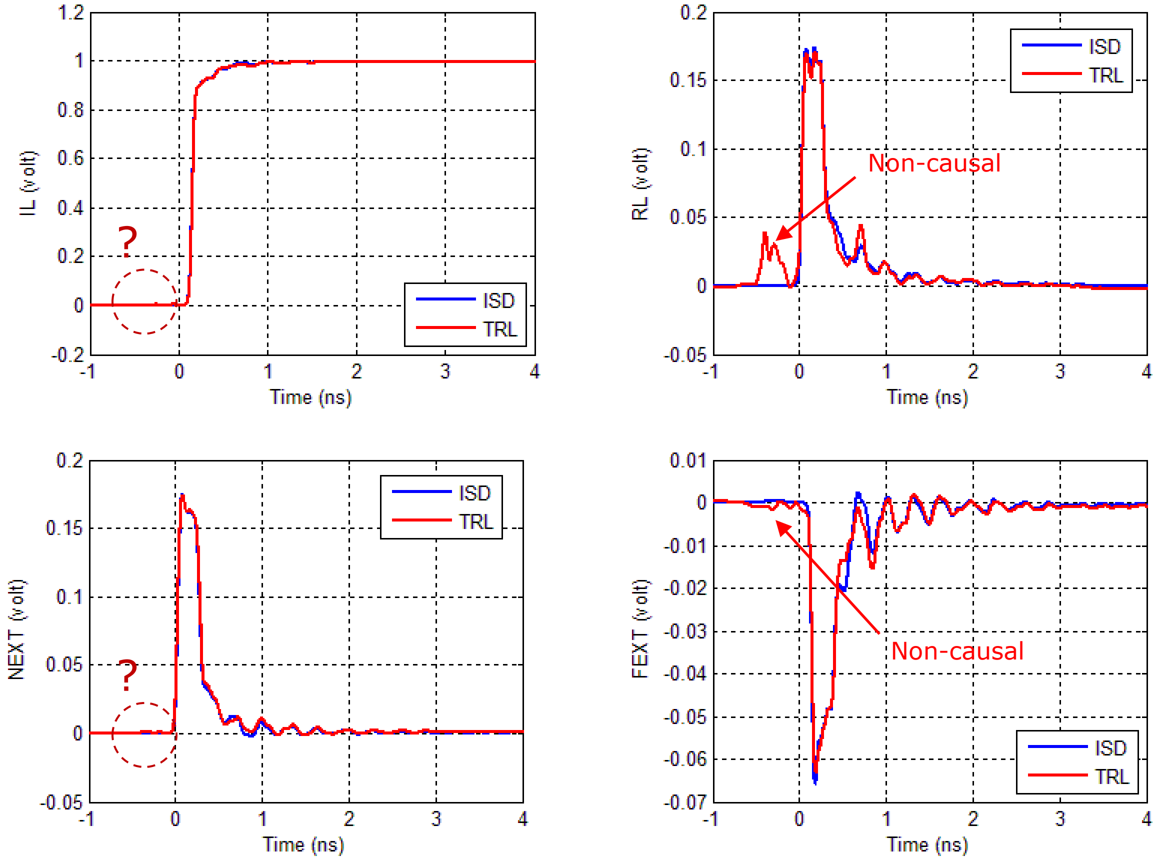
Which one is more accurate?

- TRL gives too many ripples in return loss (RL) for such a small DUT.



Non-causal ripples

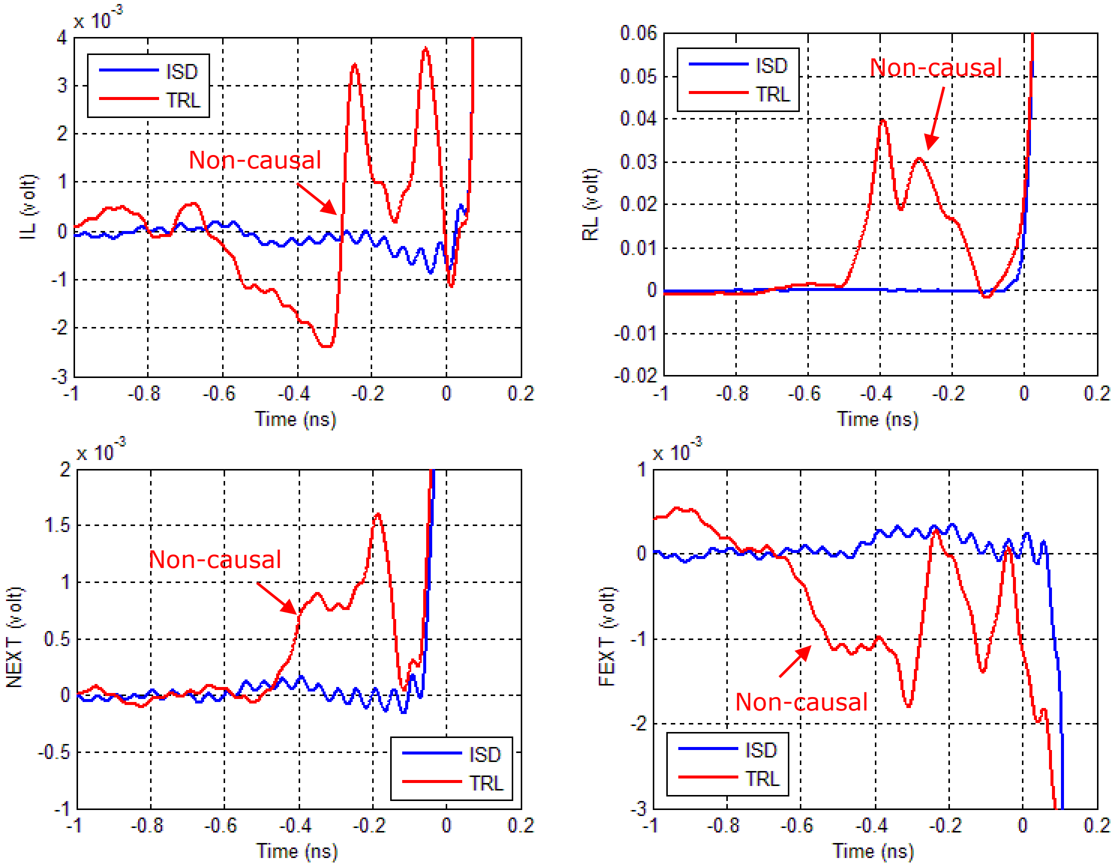
Converting S parameter into TDR/TDT shows non-causality in TRL results



Rise time = 40ps (20/80)

Zoom-in shows non-causal TRL results in all IL, RL, NEXT and FEXT

- TRL causes time-domain errors of 0.38% (IL), 25.81% (RL), 1.05% (NEXT) and 2.86% (FEXT) in this case*.

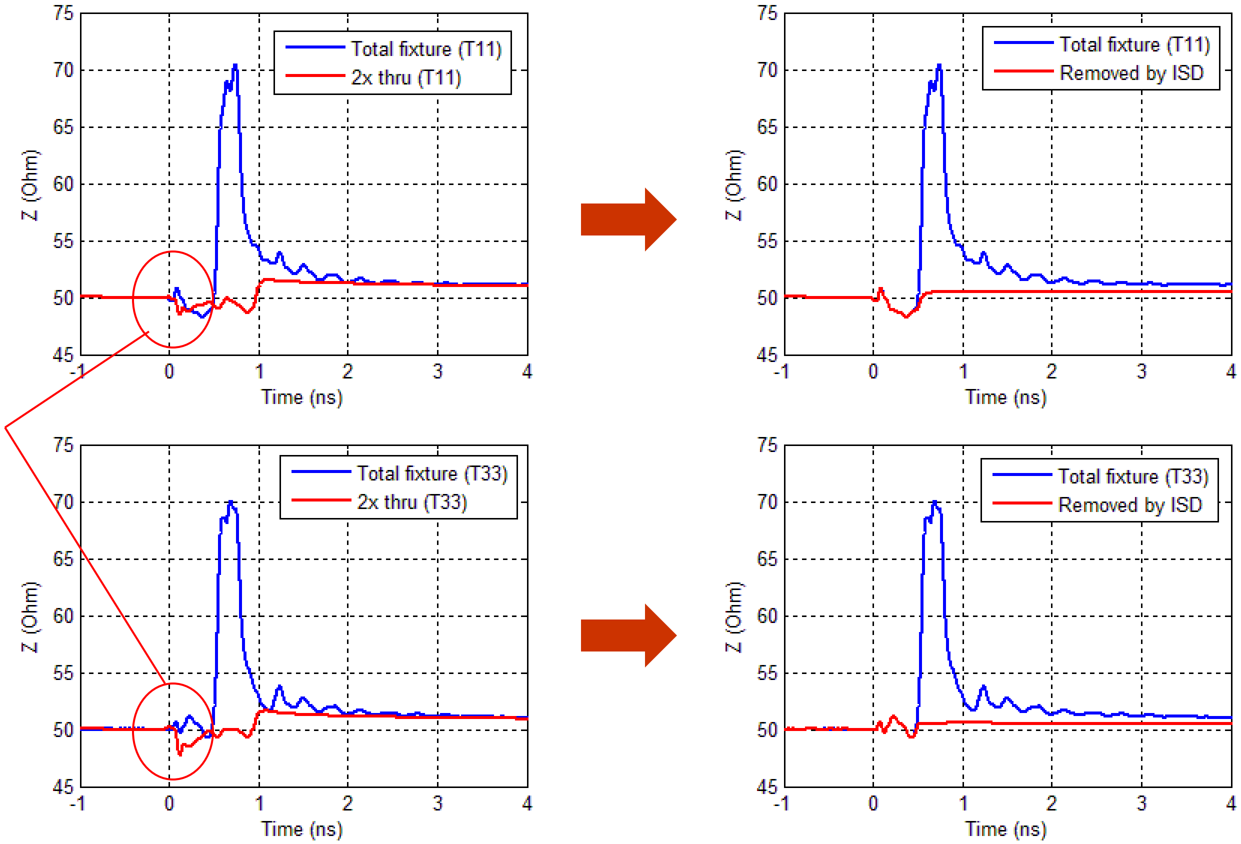


* The percentage is larger with single-bit response and/or faster rise time.

Rise time = 40ps (20/80)

How did ISD do it?

- Through optimization, ISD de-embeds fixture’s impedance exactly, independent of 2x thru’s impedance.

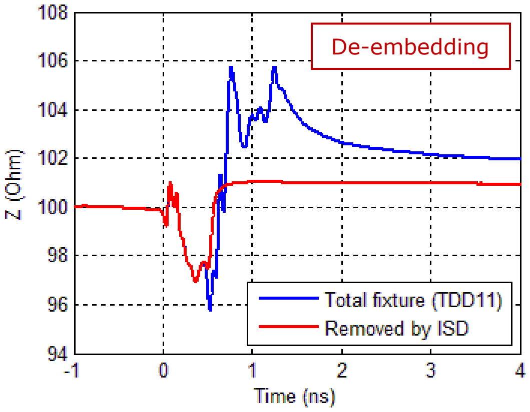


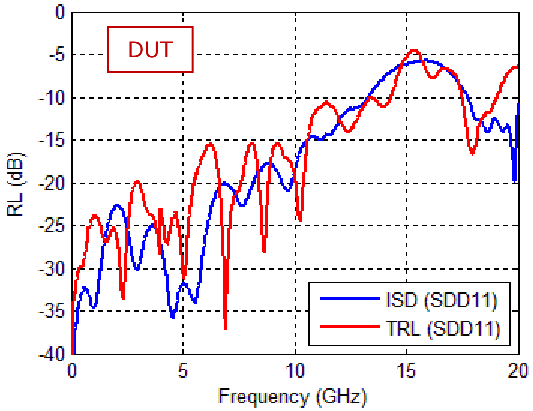
2x thru and fixture have different impedance.

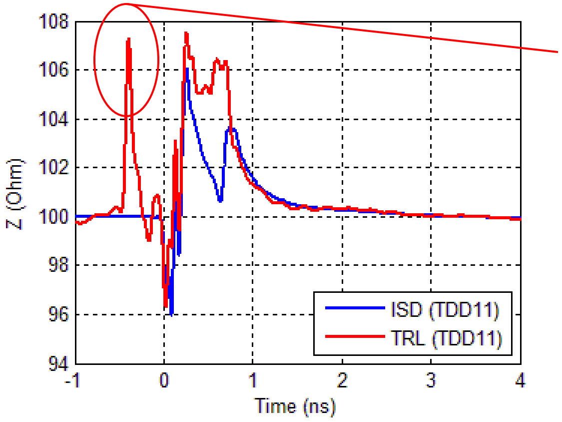
Rise time = 40ps (20/80)

TRL can give huge error in SDD11 even with small impedance variation*

- ISD is able to de-embed fixture’s differential impedance with only a single-trace 2x thru.







TRL gives more than 100% error due to causality violation.

Rise time = 40ps (20/80)

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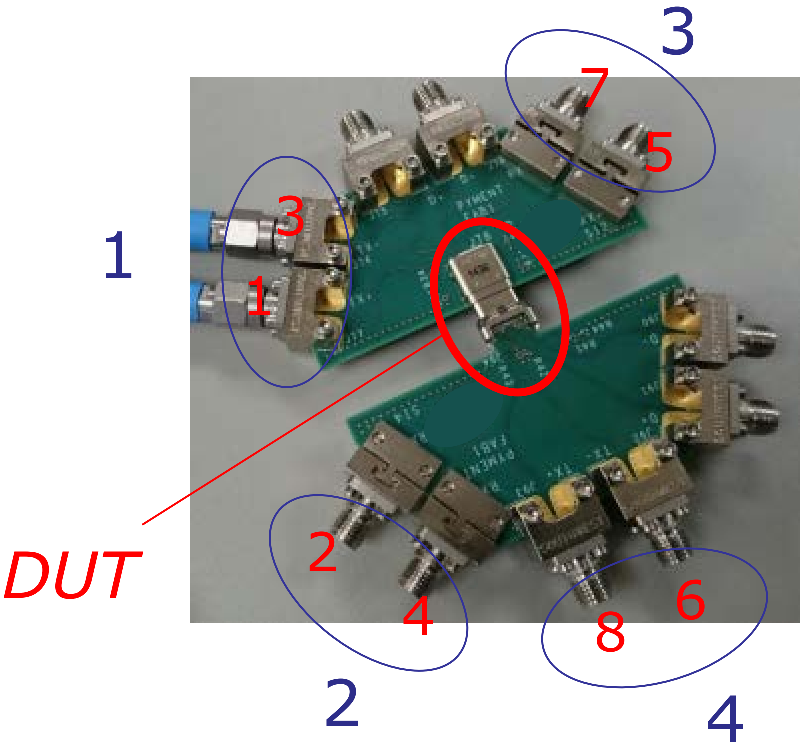
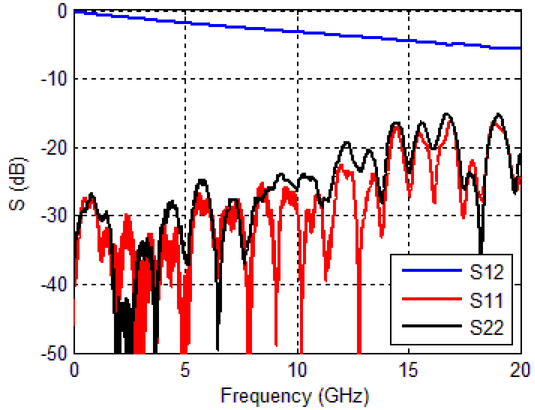
* The impedance variation between 2x thru and fixture is less than 5%. (See previous slide.)

Example 2: USB type C mated connector

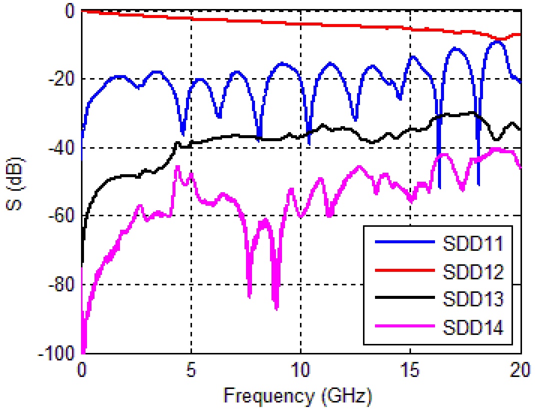
ISD vs. AFR

- Good de-embedding is crucial for meeting compliance spec.





2x thru

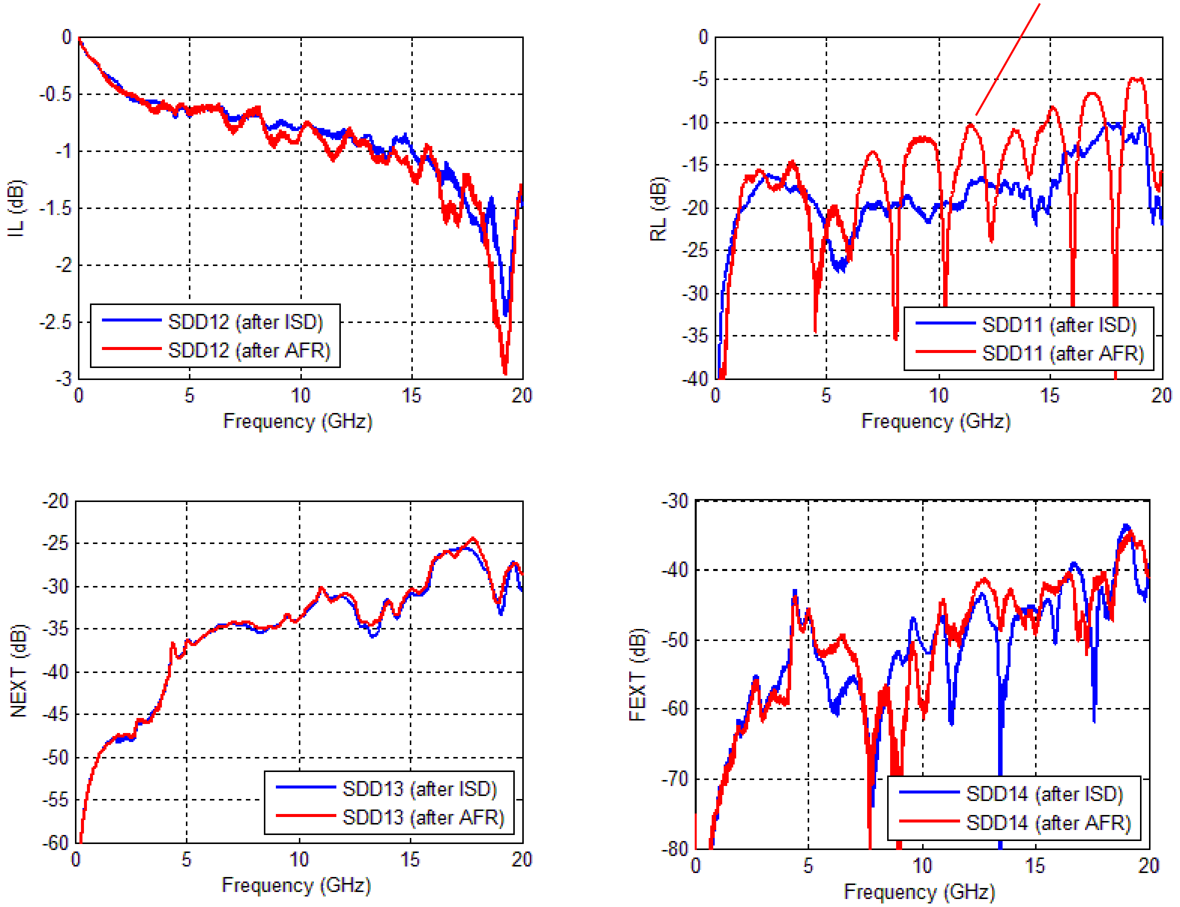


Fixture

DUT results after ISD and AFR

Which one is more accurate?

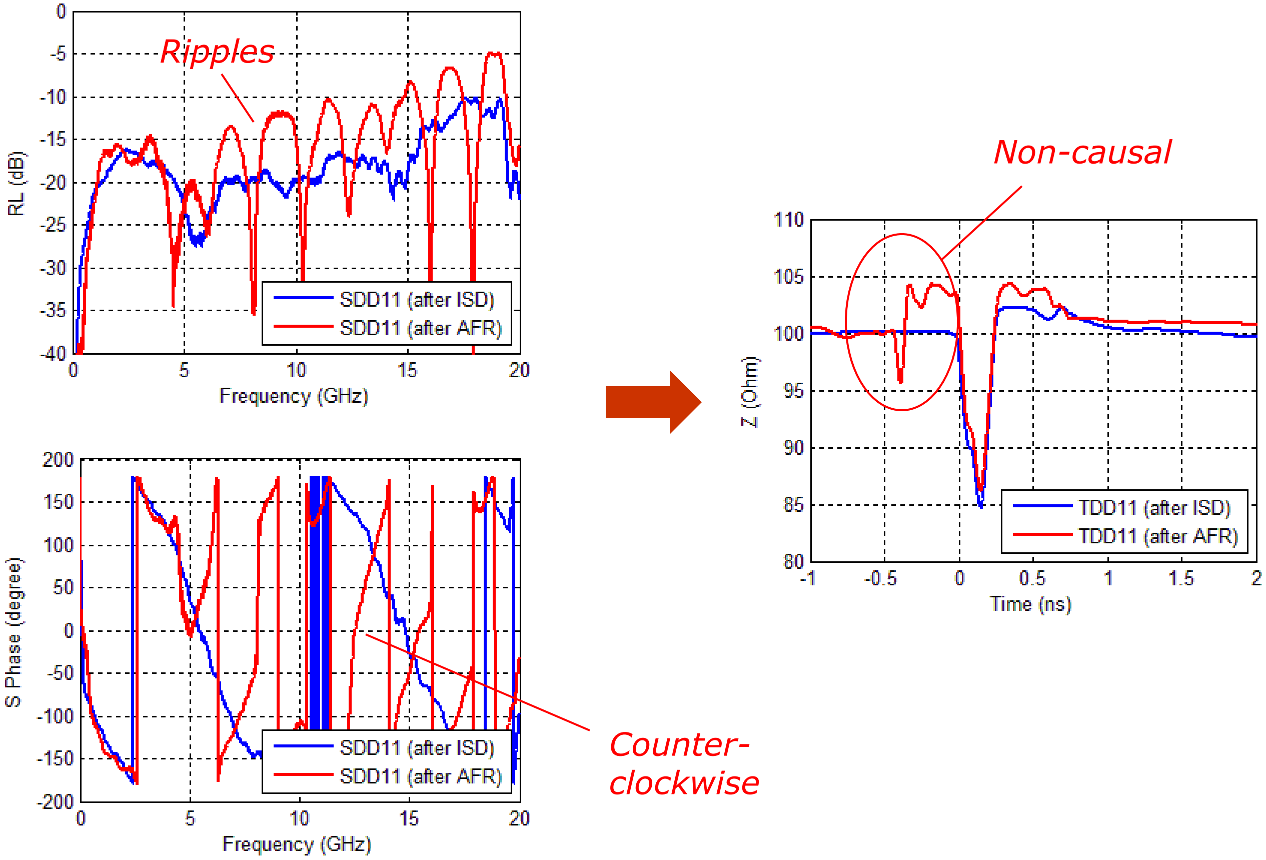
- AFR gives too many ripples in return loss (RL) for such a small DUT.



Non-causal ripples

Converting S parameter into TDR/TDT shows non-causality in AFR results

- Counterclockwise phase angle is another indication of non-causality.



Ripples

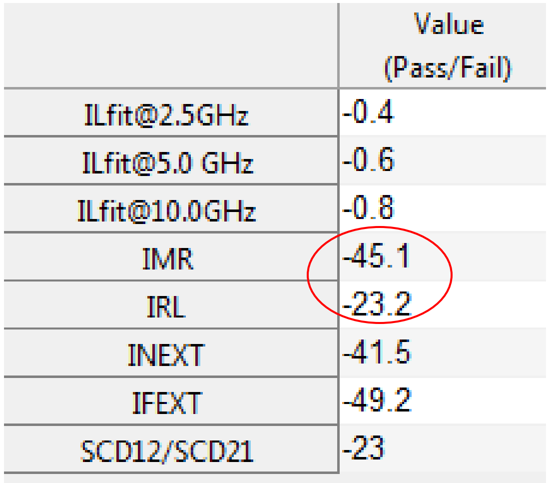
Non-causal

Counter-clockwise

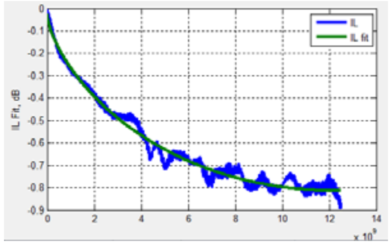
De-embedding affects pass or fail of compliance spec.

- ISD improves IMR and IRL (from compliance tool).

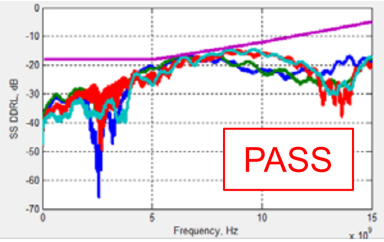
ISD



	Value (Pass/Fail)
ILfit@2.5GHz	-0.4
ILfit@5.0 GHz	-0.6
ILfit@10.0GHz	-0.8
IMR	-45.1
IRL	-23.2
INEXT	-41.5
IFEXT	-49.2
SCD12/SCD21	-23

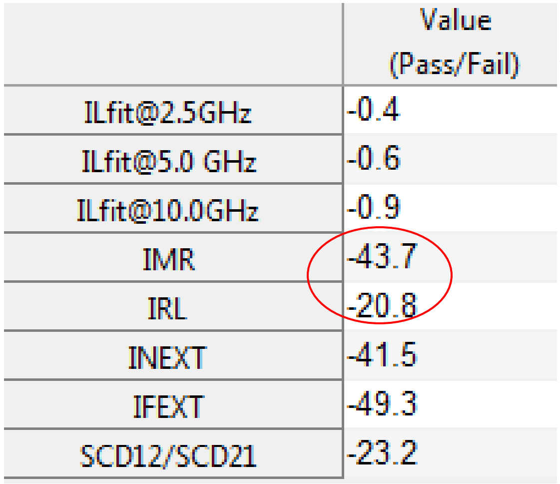


IL

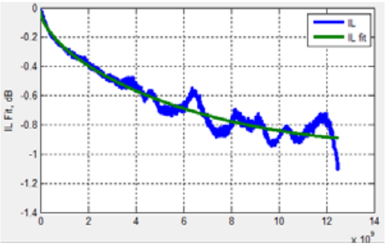


RL

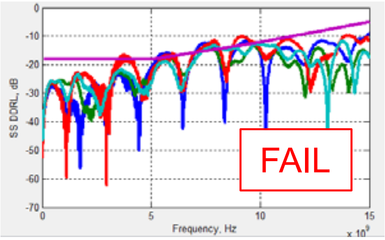
AFR



	Value (Pass/Fail)	Spec
ILfit@2.5GHz	-0.4	-0.6
ILfit@5.0 GHz	-0.6	-0.8
ILfit@10.0GHz	-0.9	-1.0
IMR	-43.7	-40
IRL	-20.8	-18
INEXT	-41.5	-44
IFEXT	-49.3	-44
SCD12/SCD21	-23.2	



IL

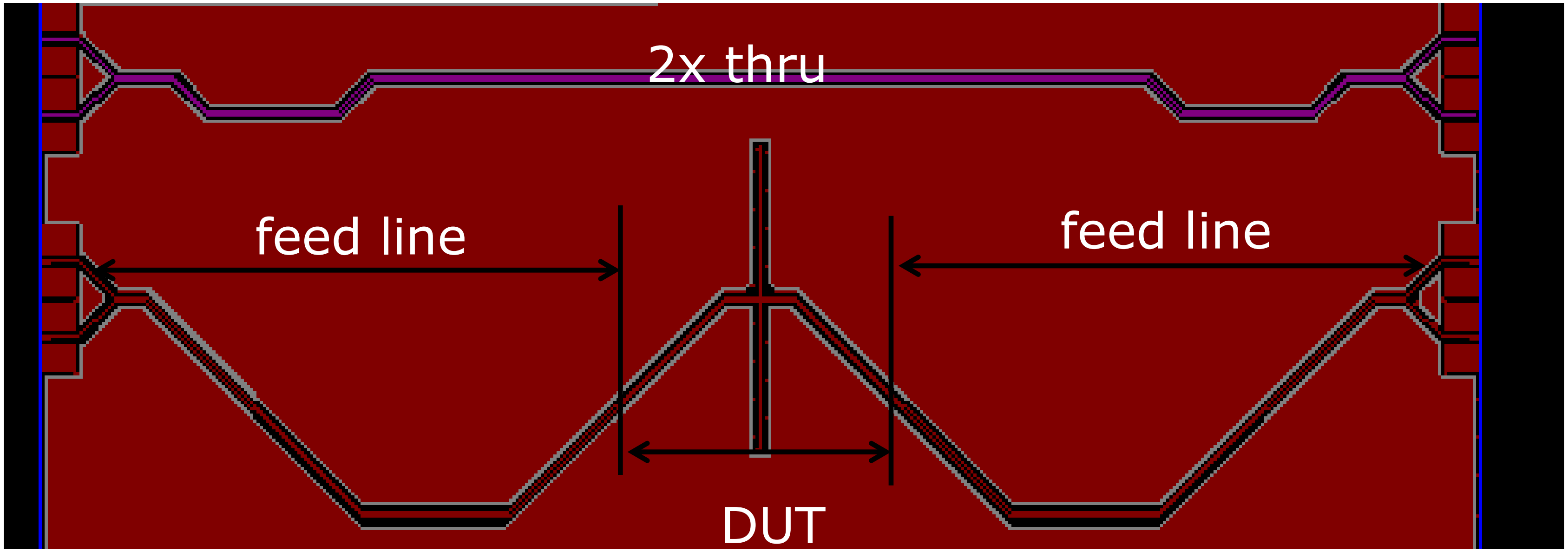


RL

Example 3: Resonator

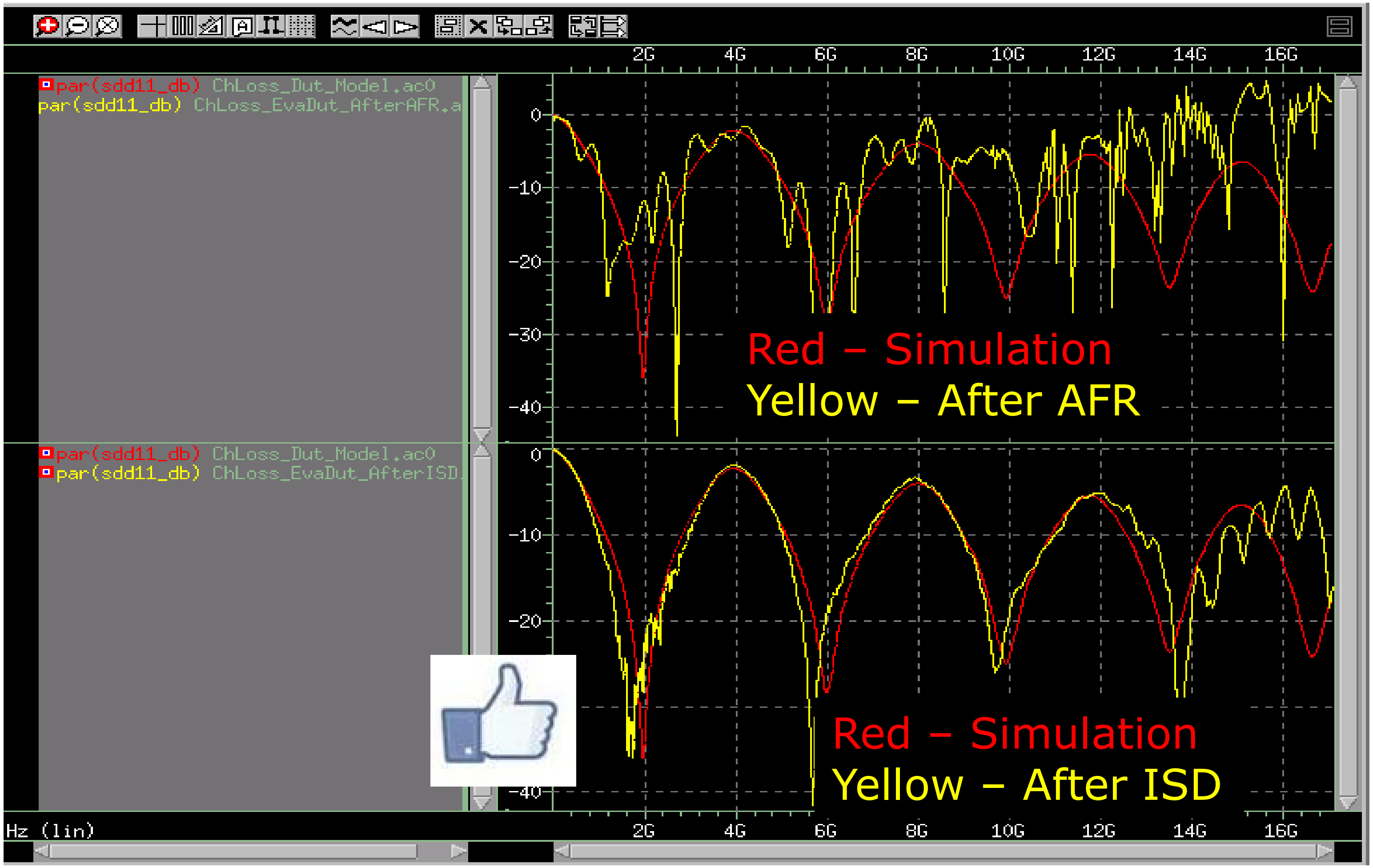
ISD vs. AFR vs. simulation

- Good de-embedding is crucial for design verification (i.e., correlation) and improvement.



SDD11

ISD correlates with simulation much better

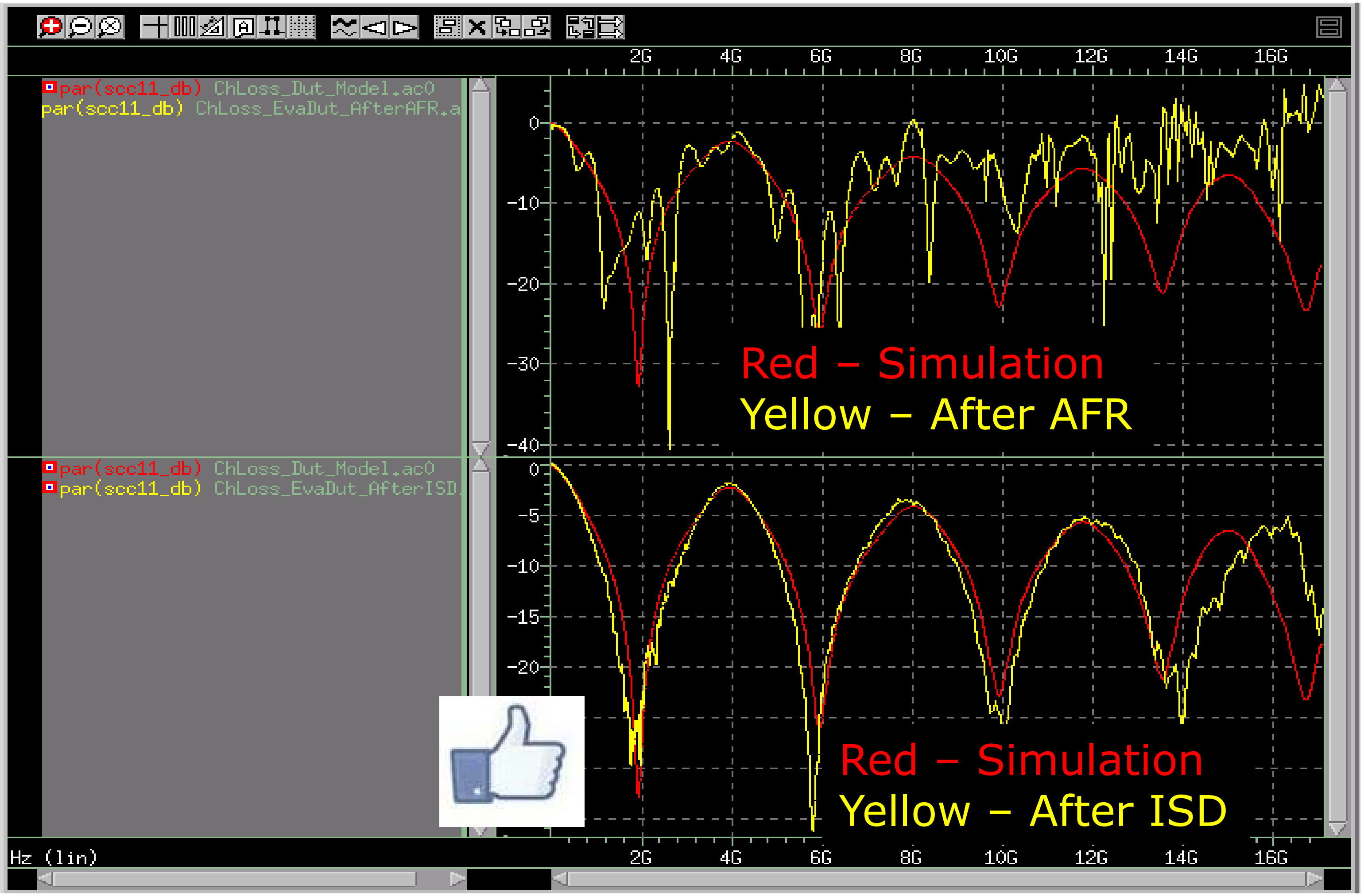


Red – Simulation
Yellow – After AFR

Red – Simulation
Yellow – After ISD

SCC11

ISD correlates with simulation much better

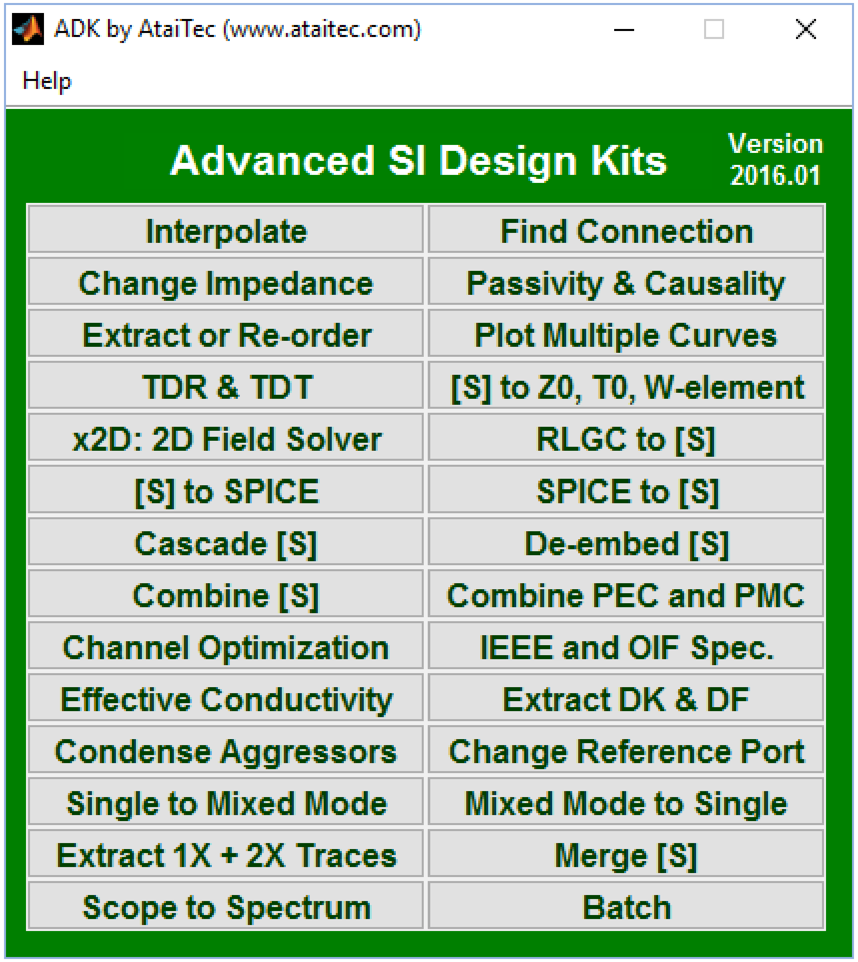


Red – Simulation
Yellow – After AFR

Red – Simulation
Yellow – After ISD

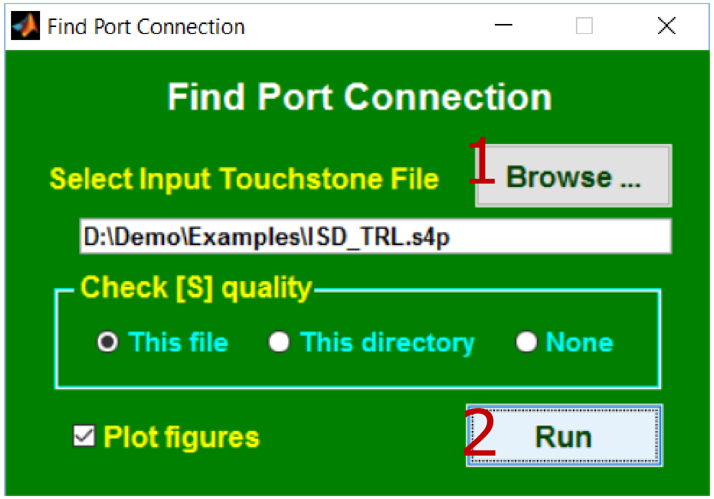
Advanced SI Design Kits (ADK)

Many mobile-apps-like SI tools in one place



- Complex SI operations, from causality correction to eye diagrams, TDR/TDT, scope de-embedding, spectral analysis, … in a few mouse clicks.
- Everything you want to do with S parameters in one place.
- Increase productivity.

Find connection

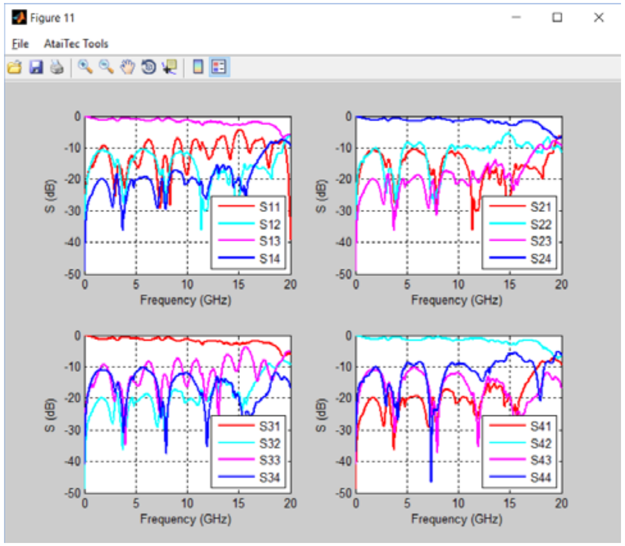


D:\Demo\Examples\ISD_TRL.s4p

Check [S] quality: ● This file ○ This directory ○ None

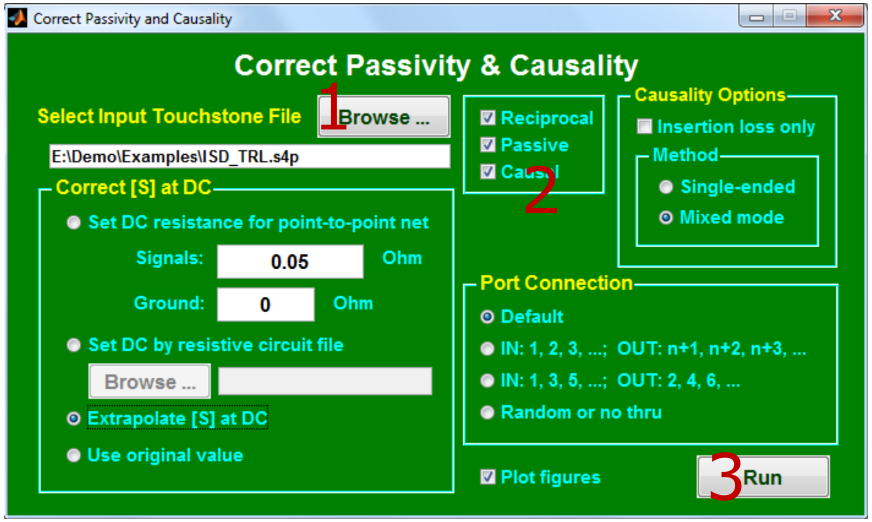
☑ Plot figures

- Quickly examine [S].
- Identify from-to connection.
- Identify near and far ends.
- Compute quality metrics.



```
File name: D:\Demo\Examples\ISD_TRL.s4p

  Total 800 points from 0.025 GHz to 20 GHz with 50 ohm Zref.

  S-parameter quality (min.):
  Reciprocity metric =  0.999992  for S(4,1)
  Passivity   metric =  0.999239  for S(1,1)
  Causality   metric =  0.556122  for S(1,1)

  From-To Connections:

    Port 1 -> 3
    Port 2 -> 4
```

Passivity & causality correction



Select Input Touchstone File: E:\Demo\Examples\ISD_TRL.s4p

☑ Reciprocal
☑ Passive
☑ Causal

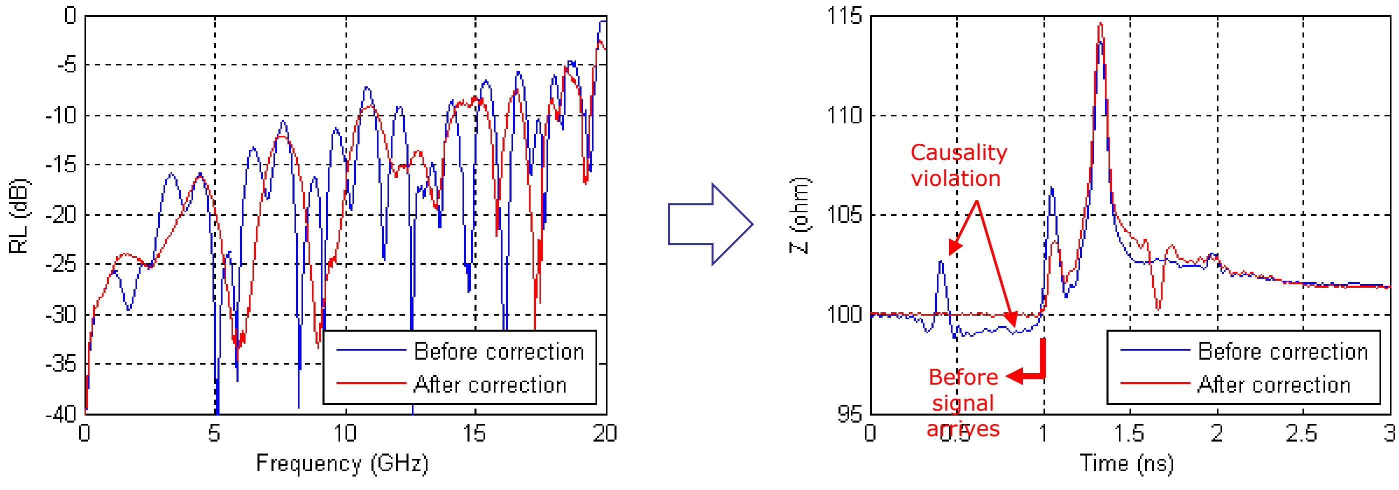
Causality Options
☐ Insertion loss only
Method
○ Single-ended
● Mixed mode

Correct [S] at DC
○ Set DC resistance for point-to-point net
Signals: 0.05 Ohm
Ground: 0 Ohm
○ Set DC by resistive circuit file
● Extrapolate [S] at DC
○ Use original value

Port Connection
● Default
○ IN: 1, 2, 3, ...; OUT: n+1, n+2, n+3, ...
○ IN: 1, 3, 5, ...; OUT: 2, 4, 6, ...
○ Random or no thru

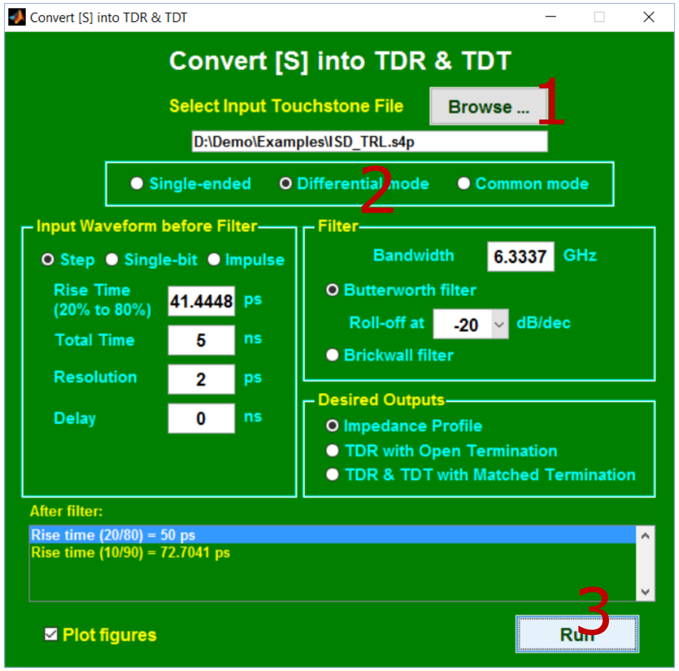
☑ Plot figures

- Multiple ways to fill in DC.
  - Separate signal and ground resistance for DC coupling in point-to-point nets.
  - Resistive circuit for



TDR @50 ps (20/80), shifted by 1ns

[S] to TDR & TDT



Convert [S] into TDR & TDT

Convert [S] into TDR & TDT

Select Input Touchstone File — Browse ... 1

D:\Demo\Examples\ISD_TRL.s4p

○ Single-ended ◉ Differential mode 2 ○ Common mode

Input Waveform before Filter

◉ Step ○ Single-bit ○ Impulse

Rise Time (20% to 80%): 41.4448 ps

Total Time: 5 ns

Resolution: 2 ps

Delay: 0 ns

Filter

Bandwidth: 6.3337 GHz

◉ Butterworth filter

Roll-off at: -20 dB/dec

○ Brickwall filter

Desired Outputs

◉ Impedance Profile

○ TDR with Open Termination

○ TDR & TDT with Matched Termination

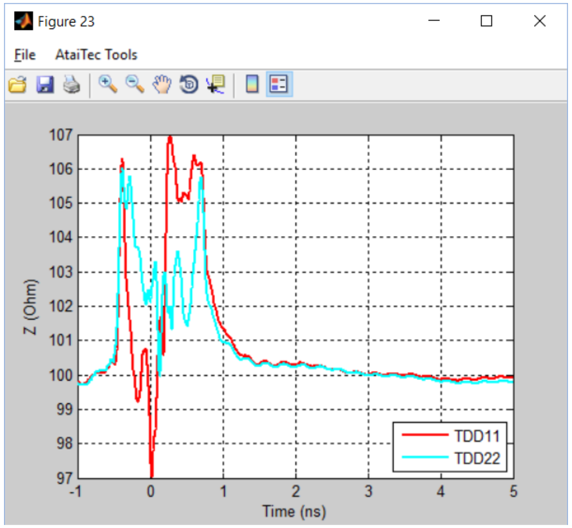
After filter:

Rise time (20/80) = 50 ps

Rise time (10/90) = 72.7041 ps

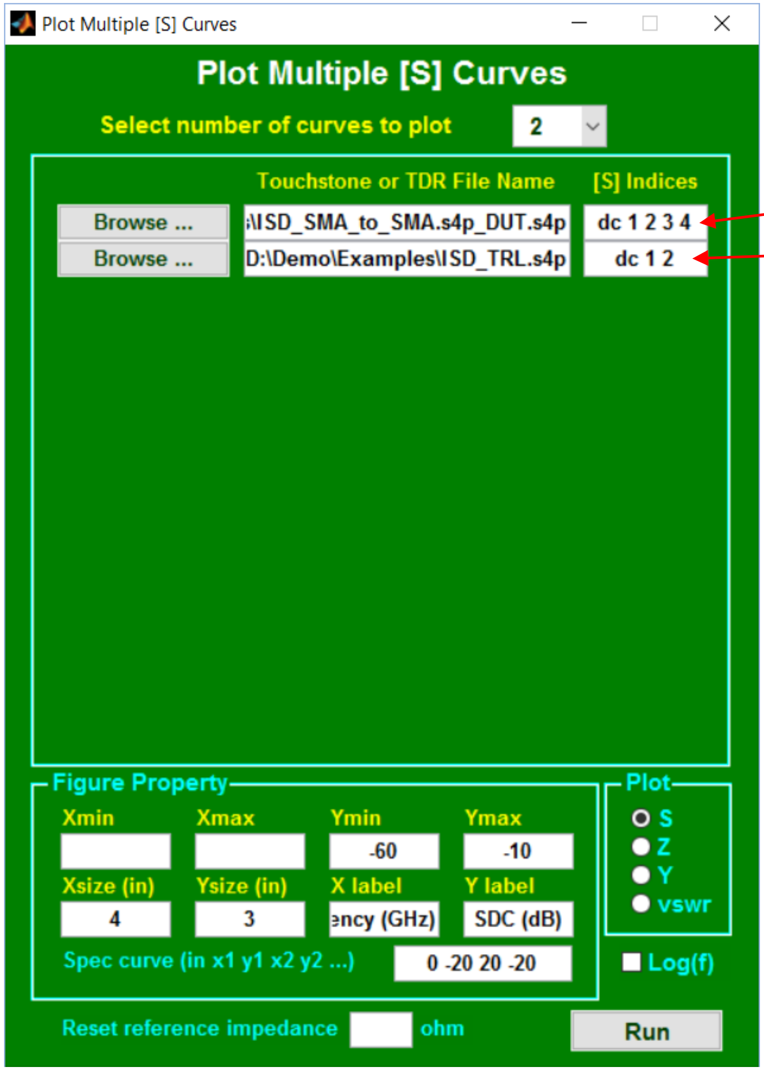
☑ Plot figures

Run 3



- Built-in filter & IFFT.
- Single-ended, differential or common mode.
- Step, single-bit or impulse response.
- Correlated with TDR equipment.

Plot [S] and time-domain curves



Plot Multiple [S] Curves

Plot Multiple [S] Curves

Select number of curves to plot: 2

	Touchstone or TDR File Name	[S] Indices
Browse ...	:\ISD_SMA_to_SMA.s4p_DUT.s4p	dc 1 2 3 4
Browse ...	D:\Demo\Examples\ISD_TRL.s4p	dc 1 2

Figure Property

Xmin	Xmax	Ymin	Ymax
		-60	-10

Xsize (in)	Ysize (in)	X label	Y label
4	3	ency (GHz)	SDC (dB)

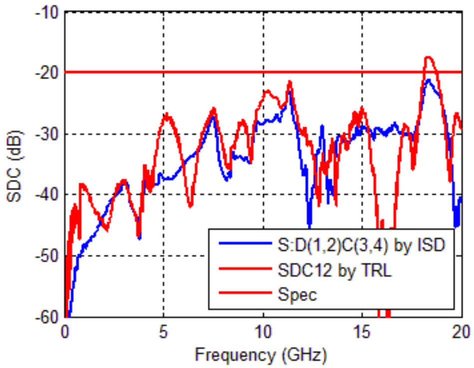
Spec curve (in x1 y1 x2 y2 ...): 0 -20 20 -20

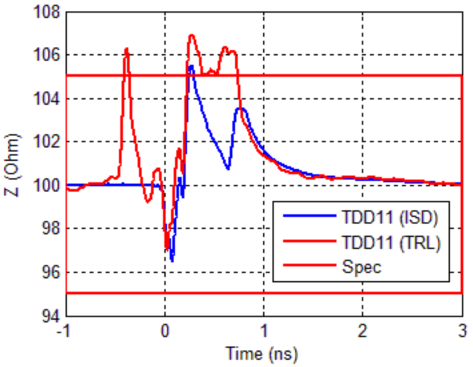
Plot: ● S ○ Z ○ Y ○ vswr

☐ Log(f)

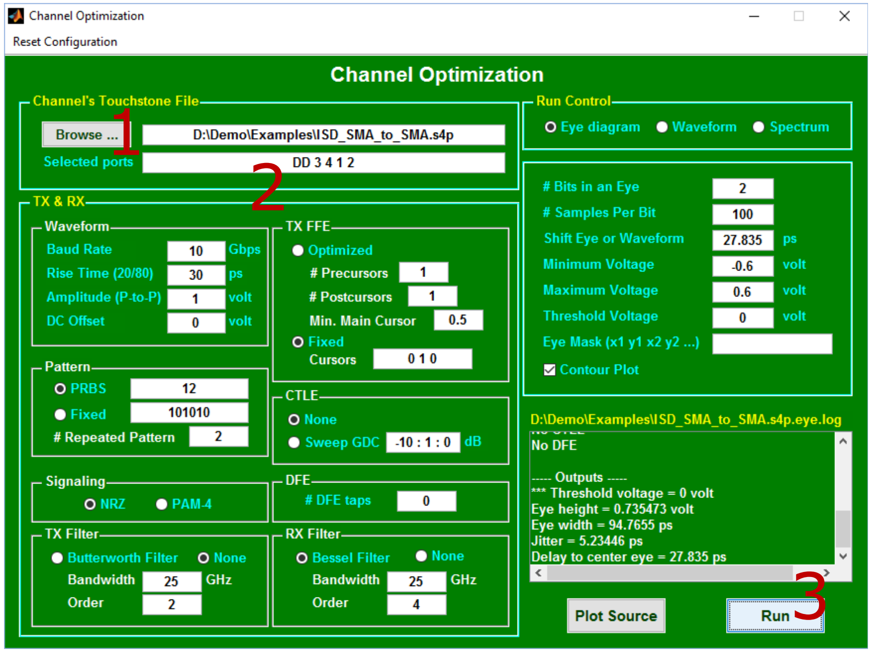
Reset reference impedance ohm

- Single-ended and mixed-mode [S] or TDR/TDT with spec.
  - Flexible port index entry.
  - Automatically identify diff pair.





Channel optimization



Channel Optimization

Channel's Touchstone File: D:\Demo\Examples\ISD_SMA_to_SMA.s4p
Selected ports: DD 3 4 1 2

TX & RX

Waveform:
Baud Rate: 10 Gbps
Rise Time (20/80): 30 ps
Amplitude (P-to-P): 1 volt
DC Offset: 0 volt

TX FFE:
○ Optimized
Precursors: 1
Postcursors: 1
Min. Main Cursor: 0.5
● Fixed
Cursors: 0 1 0

Pattern:
● PRBS: 12
○ Fixed: 101010
Repeated Pattern: 2

CTLE:
● None
○ Sweep GDC: -10 : 1 : 0 dB

Signaling:
● NRZ ○ PAM-4

DFE:
DFE taps: 0

TX Filter:
○ Butterworth Filter ● None
Bandwidth: 25 GHz
Order: 2

RX Filter:
● Bessel Filter ○ None
Bandwidth: 25 GHz
Order: 4

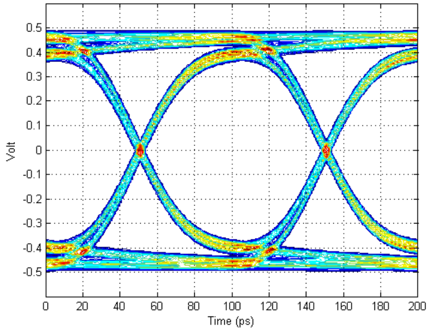
Run Control

● Eye diagram ○ Waveform ○ Spectrum

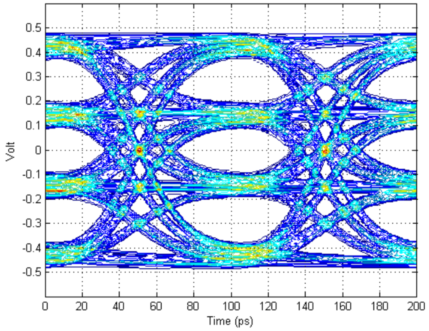
Bits in an Eye: 2
Samples Per Bit: 100
Shift Eye or Waveform: 27.835 ps
Minimum Voltage: -0.6 volt
Maximum Voltage: 0.6 volt
Threshold Voltage: 0 volt
Eye Mask (x1 y1 x2 y2 ...):
☑ Contour Plot

D:\Demo\Examples\ISD_SMA_to_SMA.s4p.eye.log

```
No DFE

----- Outputs -----
*** Threshold voltage = 0 volt
Eye height = 0.735473 volt
Eye width = 94.7655 ps
Jitter = 5.23446 ps
Delay to center eye = 27.835 ps
```



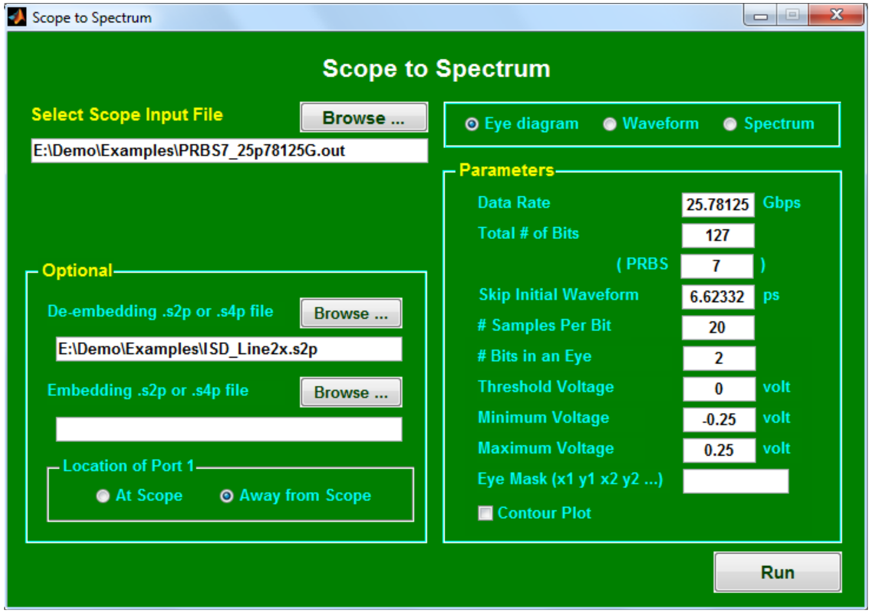
NRZ



PAM4

- [S] to eye diagram, waveform or spectrum.
- Single-ended, differential or mixed-mode.
- With or without NEXT and FEXT.
- With or without TX FFE, RX CTLE and DFE.
- Fixed or PRBS patterns.
- NRZ or PAM4

Scope embedding & de-embedding



Scope to Spectrum

Scope to Spectrum

Select Scope Input File — Browse ...

E:\Demo\Examples\PRBS7_25p78125G.out

● Eye diagram ○ Waveform ○ Spectrum

Parameters

Data Rate: 25.78125 Gbps

Total # of Bits: 127

(PRBS 7)

Skip Initial Waveform: 6.62332 ps

Samples Per Bit: 20

Bits in an Eye: 2

Threshold Voltage: 0 volt

Minimum Voltage: -0.25 volt

Maximum Voltage: 0.25 volt

Eye Mask (x1 y1 x2 y2 ...):

☐ Contour Plot

Optional

De-embedding .s2p or .s4p file — Browse ...

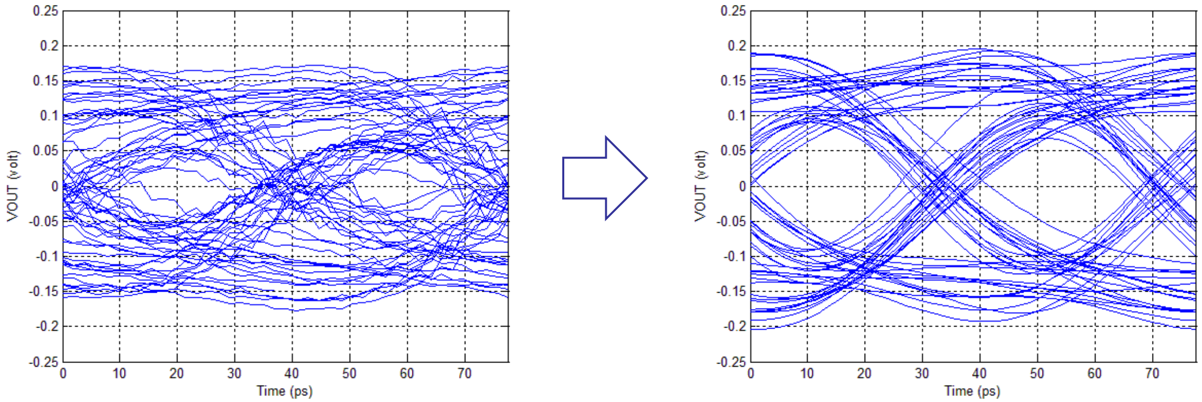
E:\Demo\Examples\ISD_Line2x.s2p

Embedding .s2p or .s4p file — Browse ...

Location of Port 1: ○ At Scope ● Away from Scope

Run

- Plot scope data in waveform, eye diagram or spectrum.
- Embed and/or de-embed [S] from scope data.



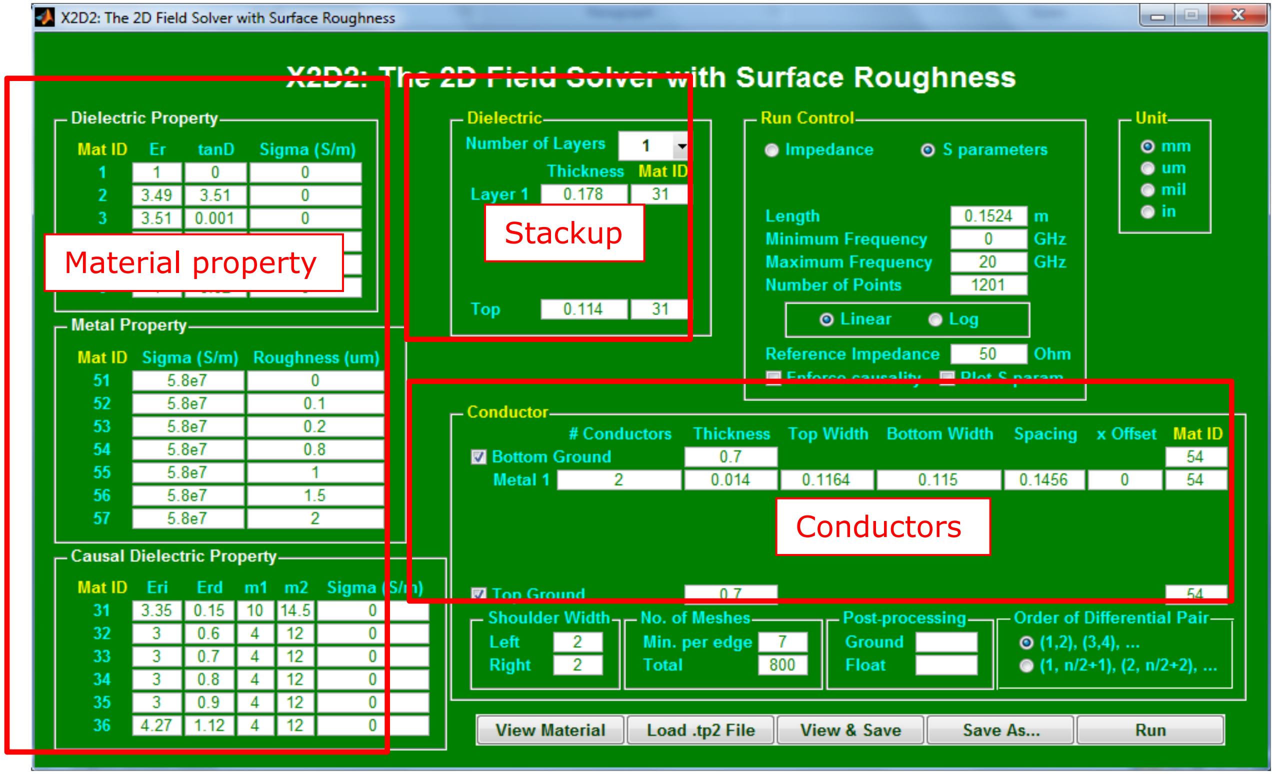
Original

After de-embedding

X2D2

Advanced 2D solver for surface roughness modeling

- Accurate 2D BEM field solver with causal dielectric and effective-conductivity surface roughness models.
- Compute impedance, RLGC matrices and S parameters.
- Create Touchstone file and frequency-dependent W-element model.



X2D2: The 2D Field Solver with Surface Roughness

Material property

Stackup

Conductors

Dielectric Property

Mat ID	Er	tanD	Sigma (S/m)
1	1	0	0
2	3.49	3.51	0
3	3.51	0.001	0

Metal Property

Mat ID	Sigma (S/m)	Roughness (um)
51	5.8e7	0
52	5.8e7	0.1
53	5.8e7	0.2
54	5.8e7	0.8
55	5.8e7	1
56	5.8e7	1.5
57	5.8e7	2

Causal Dielectric Property

Mat ID	Eri	Erd	m1	m2	Sigma (S/m)
31	3.35	0.15	10	14.5	0
32	3	0.6	4	12	0
33	3	0.7	4	12	0
34	3	0.8	4	12	0
35	3	0.9	4	12	0
36	4.27	1.12	4	12	0

Dielectric

Number of Layers: 1

	Thickness	Mat ID
Layer 1	0.178	31
Top	0.114	31

Run Control

○ Impedance ● S parameters

Length: 0.1524 m

Minimum Frequency: 0 GHz

Maximum Frequency: 20 GHz

Number of Points: 1201

● Linear ○ Log

Reference Impedance: 50 Ohm

☐ Enforce causality ☐ Plot S param

Unit

● mm
○ um
○ mil
○ in

Conductor

	# Conductors	Thickness	Top Width	Bottom Width	Spacing	x Offset	Mat ID
☑ Bottom Ground		0.7					54
Metal 1	2	0.014	0.1164	0.115	0.1456	0	54
☑ Top Ground		0.7					54

Shoulder Width

Left: 2

Right: 2

No. of Meshes

Min. per edge: 7

Total: 800

Post-processing

Ground:

Float:

Order of Differential Pair

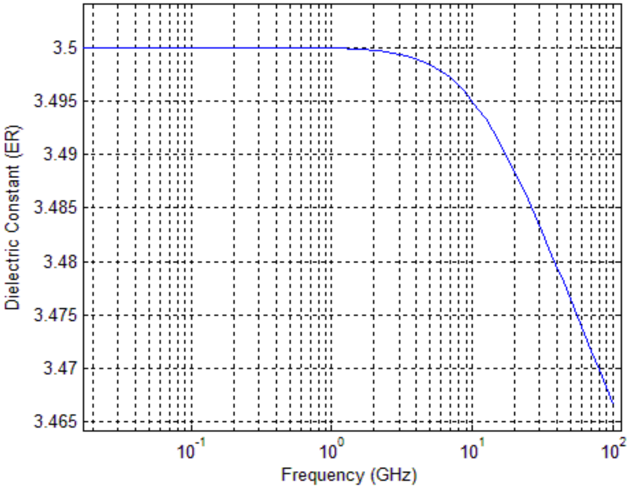
● (1,2), (3,4), ...
○ (1, n/2+1), (2, n/2+2), ...

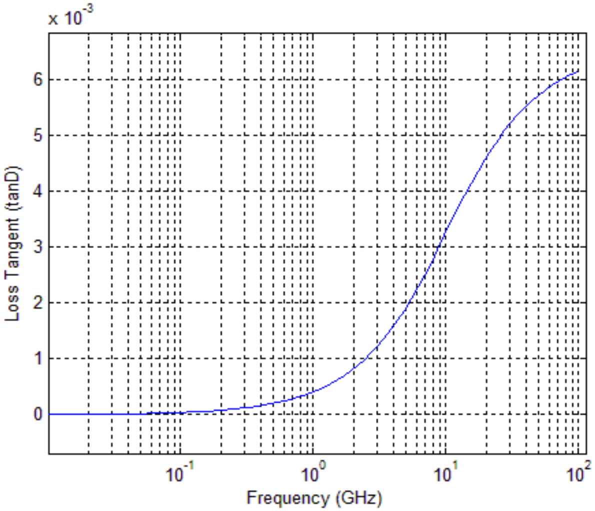
Causal dielectric model

- Wideband Debye (or Djordjevic-Sarkar) model
  - Need only four variables: ε_∞ , $\Delta\varepsilon$, m_2 , m_1

$$\varepsilon = \varepsilon_\infty + \Delta\varepsilon \cdot \frac{1}{m_2 - m_1} \cdot \log_{10}\left(\frac{10^{m_2} + i \cdot f}{10^{m_1} + i \cdot f}\right)$$

$$= \varepsilon_r \cdot (1 - i \cdot \tan\delta)$$

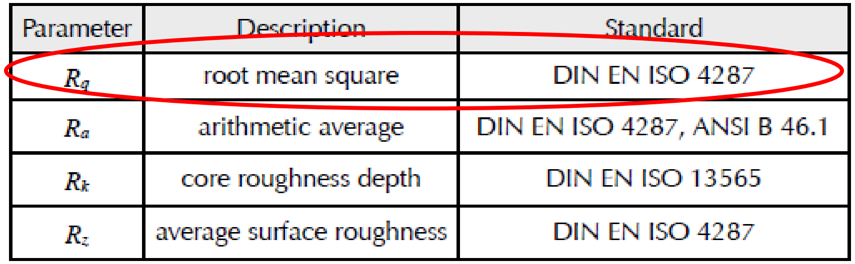




$$\varepsilon_\infty = 3.35 \ , \ \Delta\varepsilon = 0.15 \ , \ m_2 = 10 \ , \ m_1 = 14.5$$

Surface roughness model

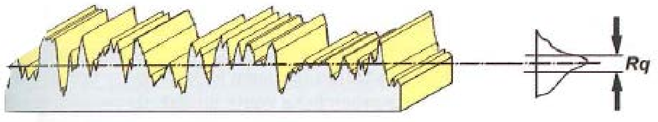
- Effective conductivity (by G. Gold & K. Helmreich at DesignCon 2014) needs only two variables: σ_{bulk} , R_q



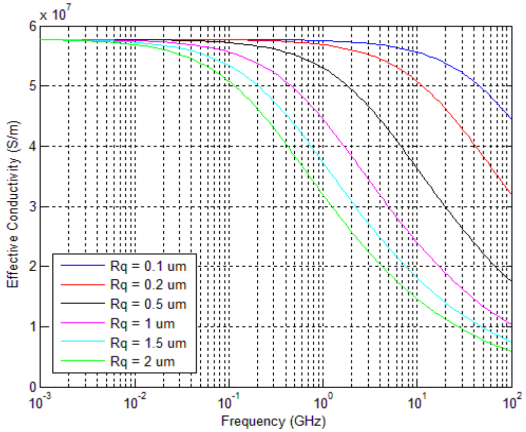
Parameter	Description	Standard
R_q	root mean square	DIN EN ISO 4287
R_a	arithmetic average	DIN EN ISO 4287, ANSI B 46.1
R_k	core roughness depth	DIN EN ISO 13565
R_z	average surface roughness	DIN EN ISO 4287

Table 1: *Statistical parameters to describe surface roughness*

$$\sigma(x)=\sigma_{bulk}\cdot CDF(x)=\sigma_{bulk}\cdot\int_{-\infty}^{x}PDF(x)du=\sigma_{bulk}\cdot\int_{-\infty}^{x}e^{-\frac{u^2}{2R_q^2}}du$$



- Numerically solving $\nabla^2\overline{B}-j\omega\mu\sigma\overline{B}+\frac{\nabla\sigma}{\sigma}\times\left(\nabla\times\overline{B}\right)=0$ and equating power to that of smooth surface gives σ_{eff}

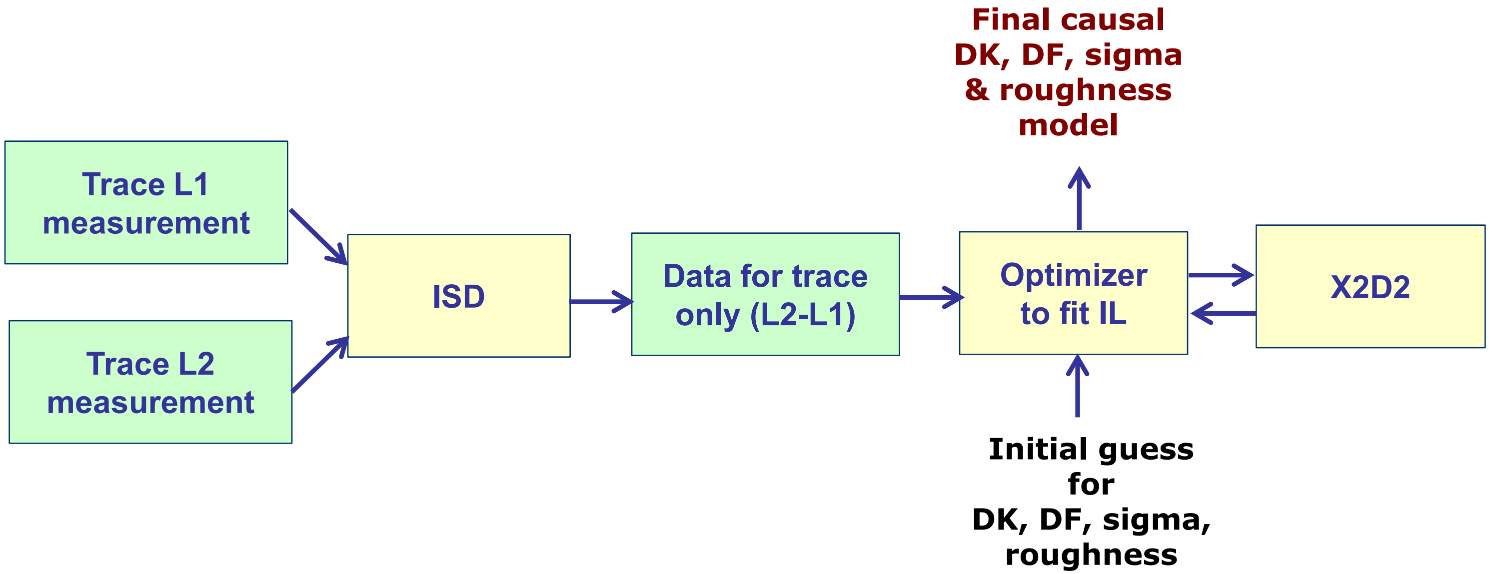


$\sigma_{bulk}=5.8\times10^7$ s/m

- ❖ Simple
- ❖ Work well with field solver
- ❖ Give effect of roughness on all IL, RL, NEXT and FEXT

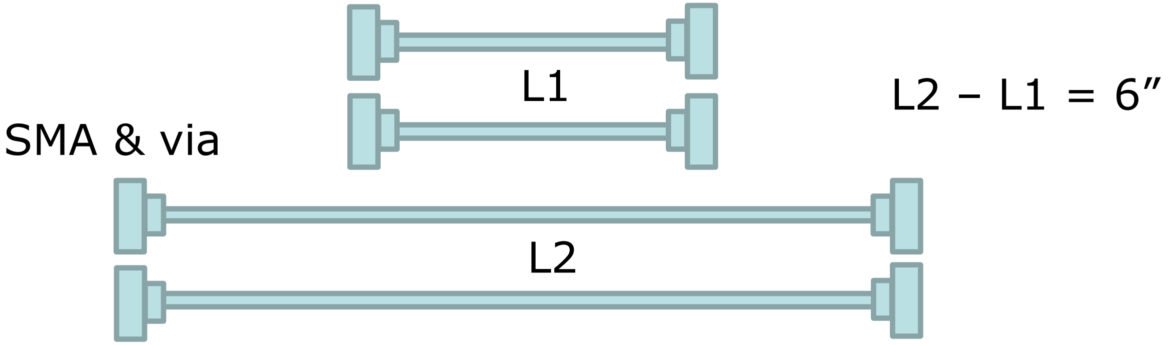
Using ISD and X2D2 to extract material property

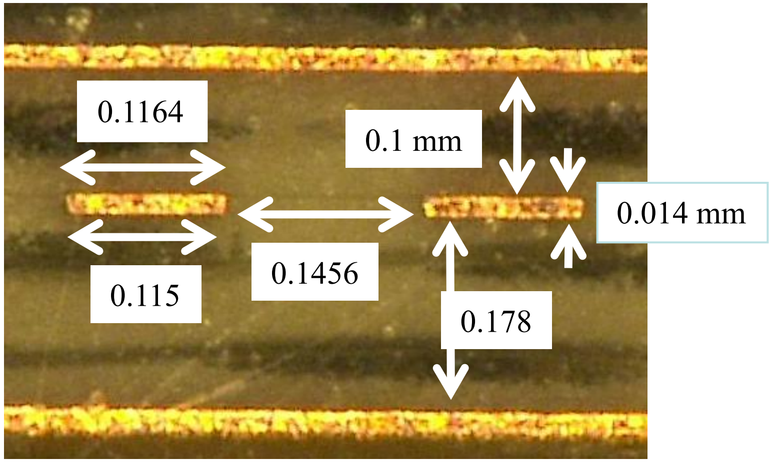
- Measure two traces of different length (L1 & L2).
- Use ISD to extract trace-only data.
- Extract causal DK, DF and surface roughness models by running X2D2 to fit IL in both magnitude and phase.



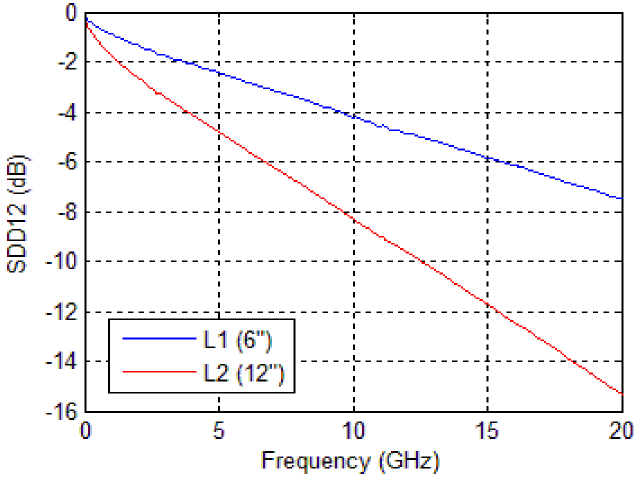
Example

- Two differential stripline traces of different length (L1 & L2) are measured.



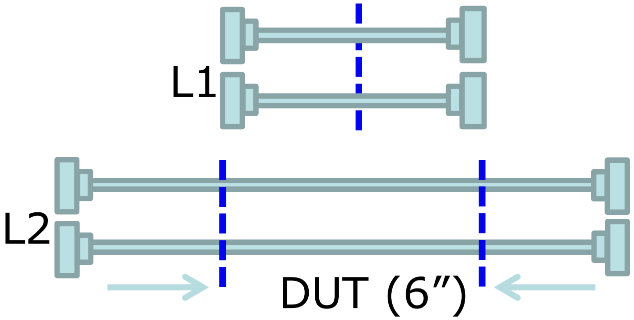


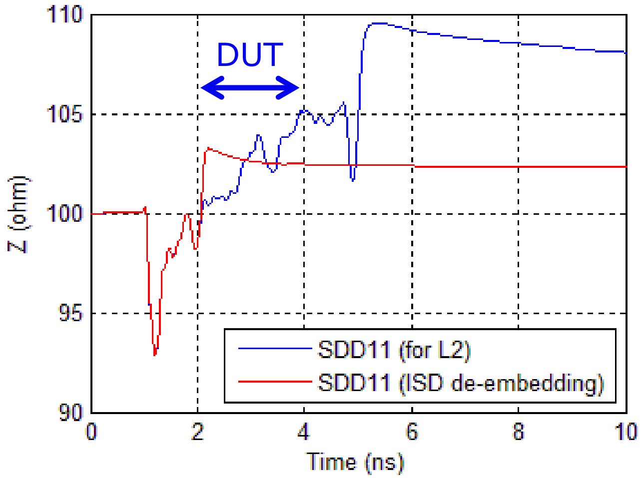
Cross section



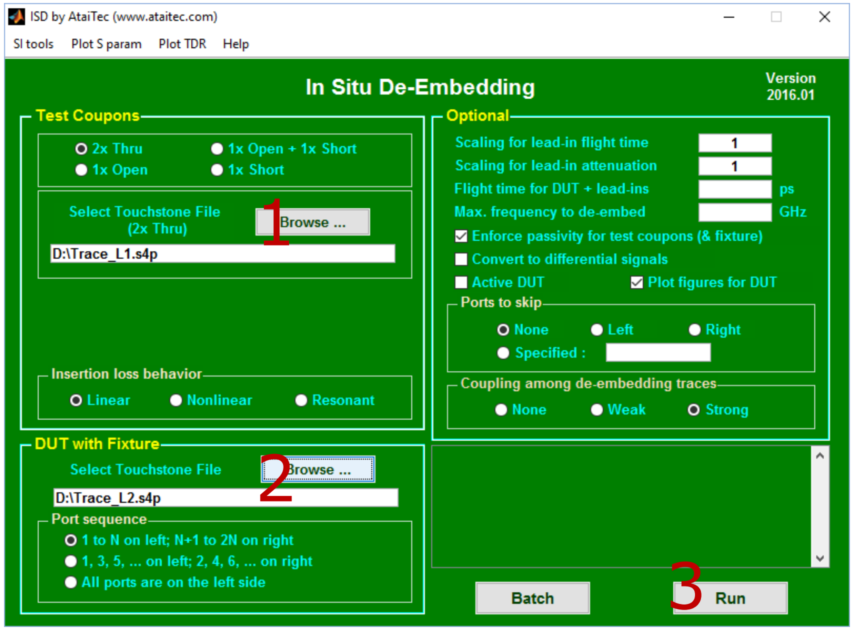
Using ISD to extract trace-only data

- ISD uses L1 as 2x thru and matches L2 impedance to extract DUT (6″ trace).





Rise time (20/80) = 50 ps



In Situ De-Embedding

Version 2016.01

Test Coupons

● 2x Thru ○ 1x Open + 1x Short
○ 1x Open ○ 1x Short

Select Touchstone File (2x Thru) Browse ...

D:\Trace_L1.s4p

Insertion loss behavior

● Linear ○ Nonlinear ○ Resonant

Optional

Scaling for lead-in flight time: 1
Scaling for lead-in attenuation: 1
Flight time for DUT + lead-ins: ps
Max. frequency to de-embed: GHz

☑ Enforce passivity for test coupons (& fixture)
☐ Convert to differential signals
☐ Active DUT ☑ Plot figures for DUT

Ports to skip

● None ○ Left ○ Right
○ Specified :

Coupling among de-embedding traces

○ None ○ Weak ● Strong

DUT with Fixture

Select Touchstone File Browse ...

D:\Trace_L2.s4p

Port sequence

● 1 to N on left; N+1 to 2N on right
○ 1, 3, 5, ... on left; 2, 4, 6, ... on right
○ All ports are on the left side

Batch Run

Using X2D2 to compare different models

Optimized model gives the desired material property

- Model A (manufacturer's) – DK=3.51, DF=0.004,

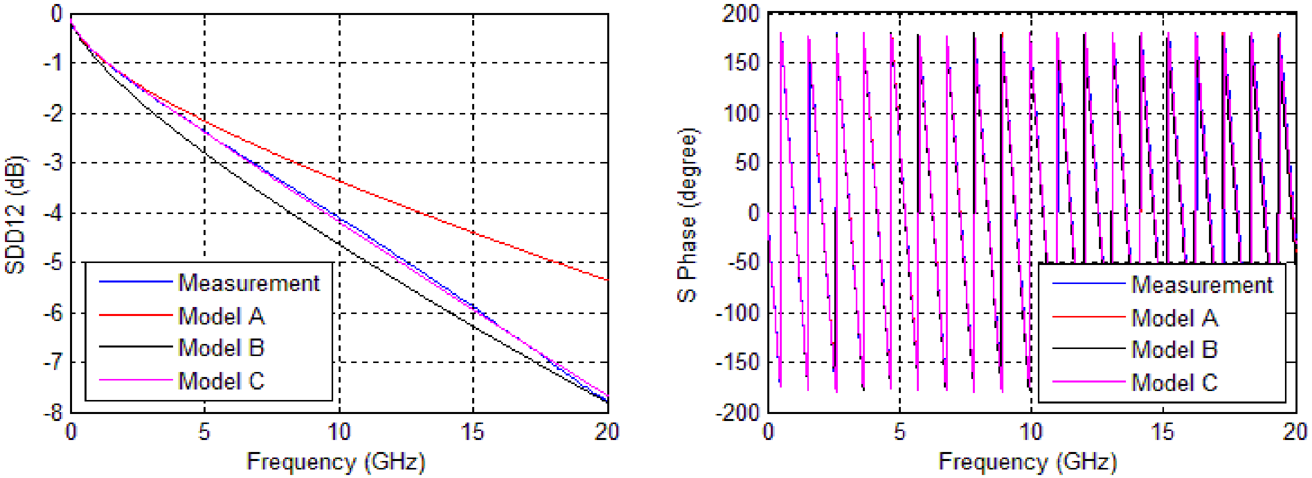
$$\sigma_{bulk} = 5.8\times10^{7}\ \text{s/m}\,,\ R_q = 0$$

- Model B (intermediate) – DK=3.51, DF=0.004,

$$\sigma_{bulk} = 5.8\times10^{7}\ \text{s/m},\ R_q = 1\ \mu m$$

- Model C (optimized) – $\varepsilon_\infty = 3.35\,,\ \Delta\varepsilon = 0.15\,,\ m_2 = 10\,,\ m_1 = 14.5$

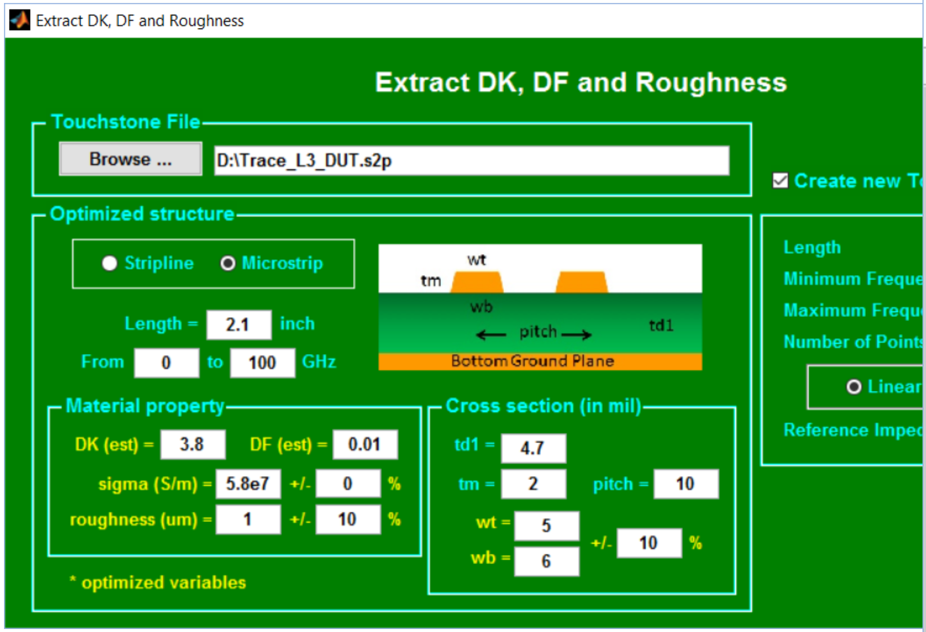
$$\sigma_{bulk} = 5.8\times10^{7}\text{s/m}\,,\ R_q = 0.8\ \mu m$$



Fitting differential IL in both magnitude and phase

Automated extraction of DK, DF, roughness and 2D cross section

- Built-in templates for microstrips and striplines.
  - Other templates (such as cable) can be easily added.
- Easily create trace S param for any length and to any frequency.



Extract DK, DF and Roughness

Extract DK, DF and Roughness

Touchstone File: D:\Trace_L3_DUT.s2p

☑ Create new T

Optimized structure: ○ Stripline ● Microstrip

Length = 2.1 inch

From 0 to 100 GHz

Material property

DK (est) = 3.8 DF (est) = 0.01

sigma (S/m) = 5.8e7 +/- 0 %

roughness (um) = 1 +/- 10 %

Cross section (in mil)

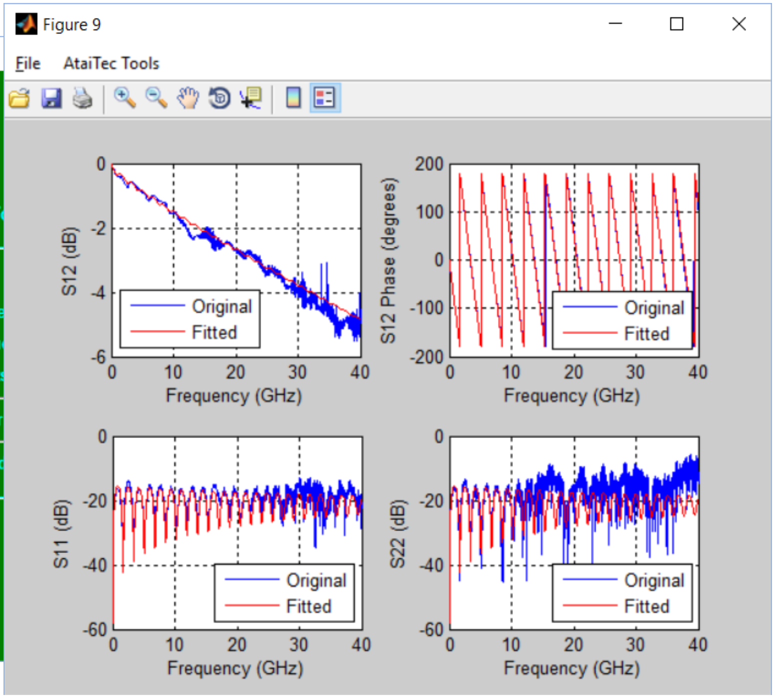
td1 = 4.7

tm = 2 pitch = 10

wt = 5

wb = 6 +/- 10 %

* optimized variables

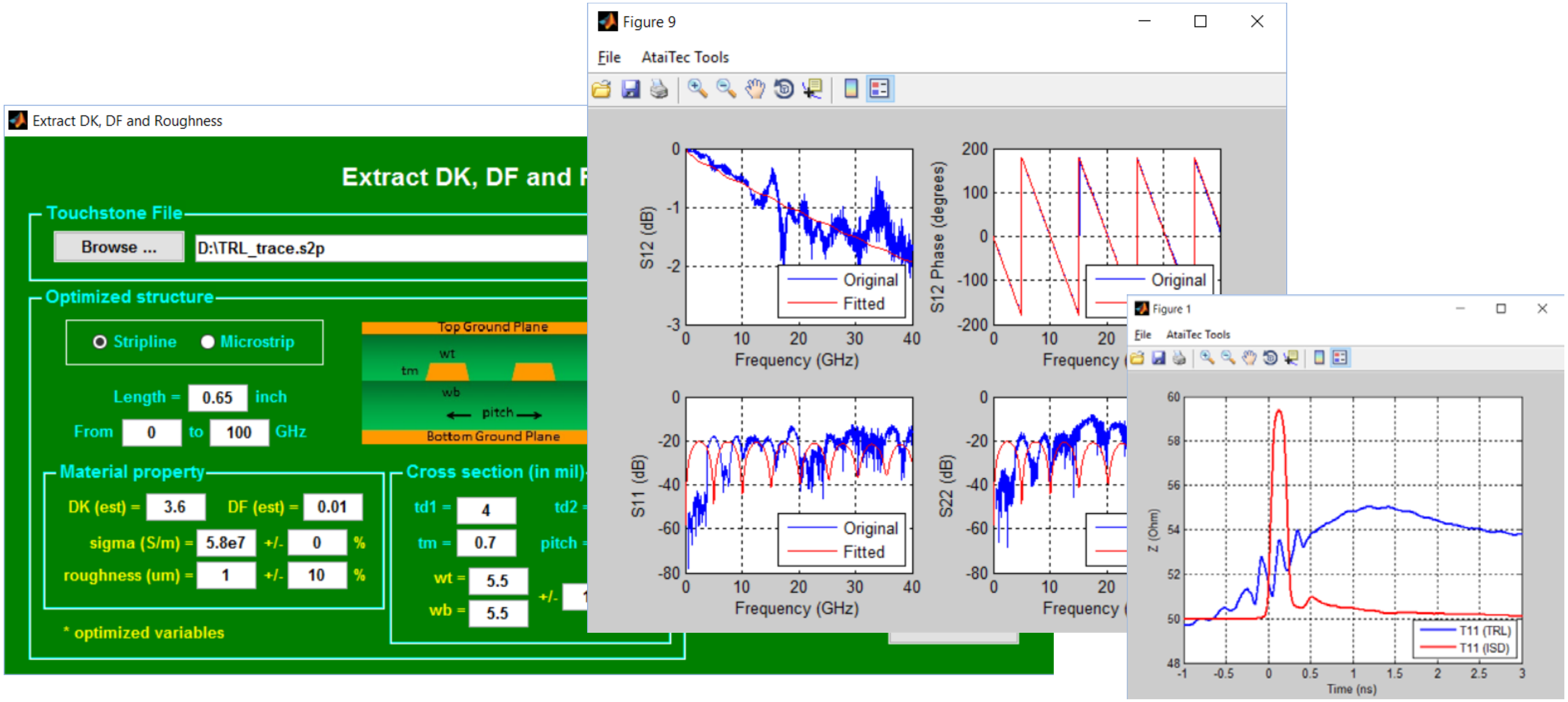


Note: We can fit RL from ISD but not from TRL because TRL's RL is often non-physical.

RL is crucial for DK extraction

Use ISD instead of TRL results for extraction

- TRL gives non-physical RL and will be impossible to fit. Matching RL is crucial because it affects DK and cross section (and therefore length, DF and roughness).



Extract DK, DF and Roughness

Touchstone File: D:\TRL_trace.s2p

Optimized structure: ● Stripline ○ Microstrip

Length = 0.65 inch

From 0 to 100 GHz

Material property

DK (est) = 3.6 DF (est) = 0.01

sigma (S/m) = 5.8e7 +/- 0 %

roughness (um) = 1 +/- 10 %

Cross section (in mil)

td1 = 4

tm = 0.7

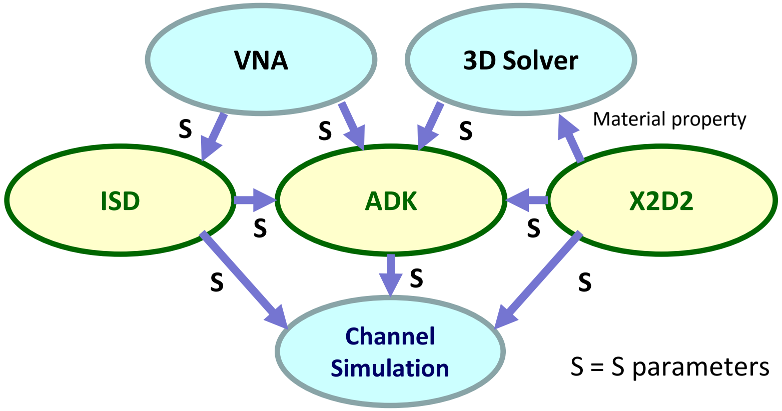
wt = 5.5

wb = 5.5

* optimized variables

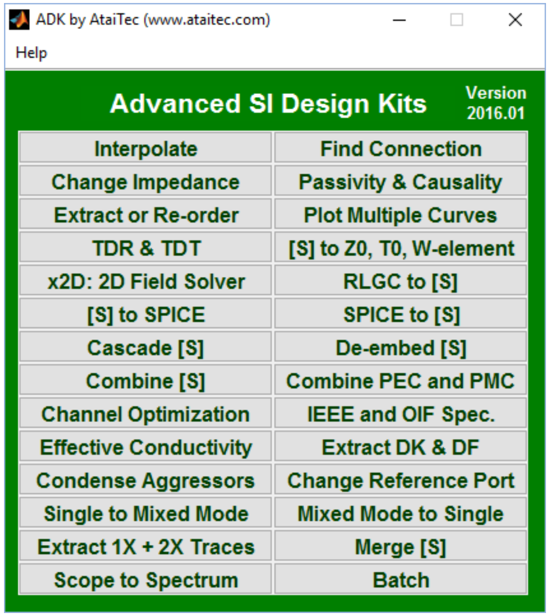
Summary

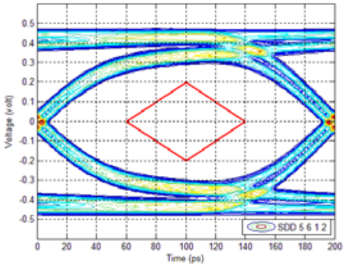
- AtaiTec’s mobile-apps-like signal integrity software helps improve productivity with most applications in ~3 clicks.
  - ISD fixes causality problems commonly found in de-embedding.
  - ADK is a one-stop shop for many SI applications.
  - X2D2 models and extracts DK, DF and surface roughness.

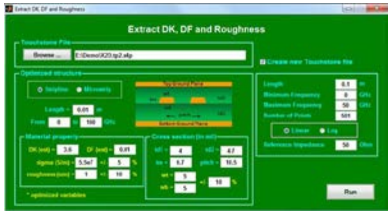

VNA
3D Solver
Material property
ISD
ADK
X2D2
Channel Simulation
S

S = S parameters

AtaiTec enhanced flow



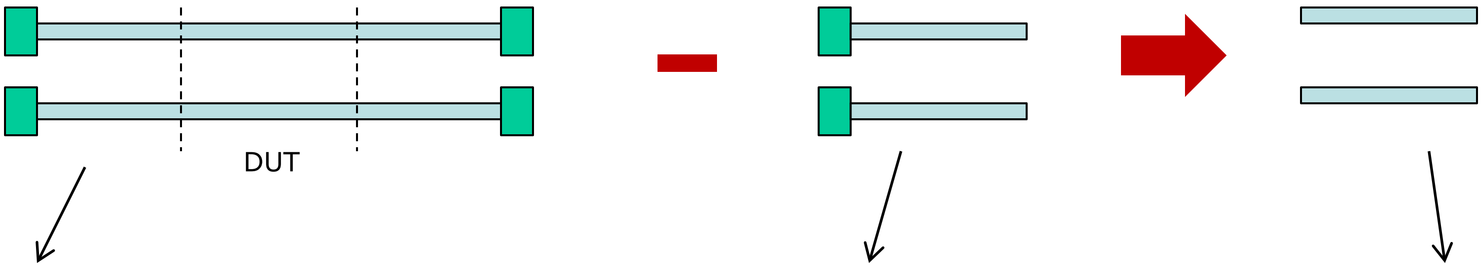




Appendix

1x Open De-embedding

ISD’s new 1x open de-embedding needs only one 1x open test coupon



Fixture + DUT

0.5″ microstrip

4.5″ stripline

0.5″ microstrip

DUT

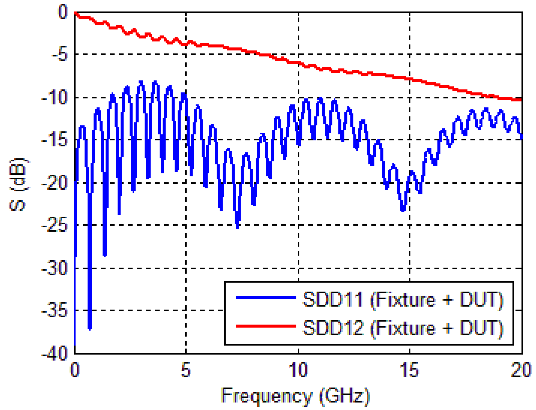
1x open

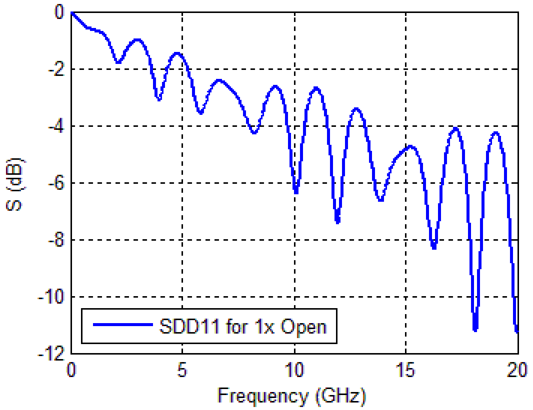
0.5″ microstrip

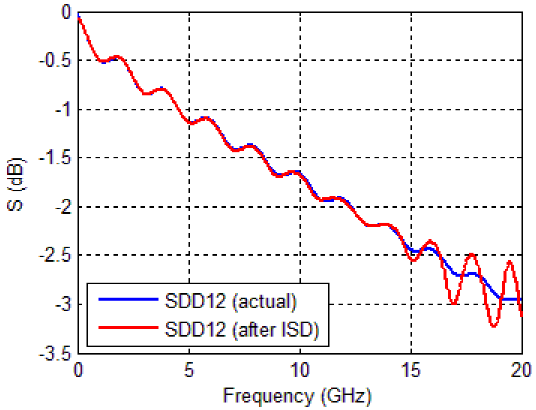
1.5″ stripline

DUT

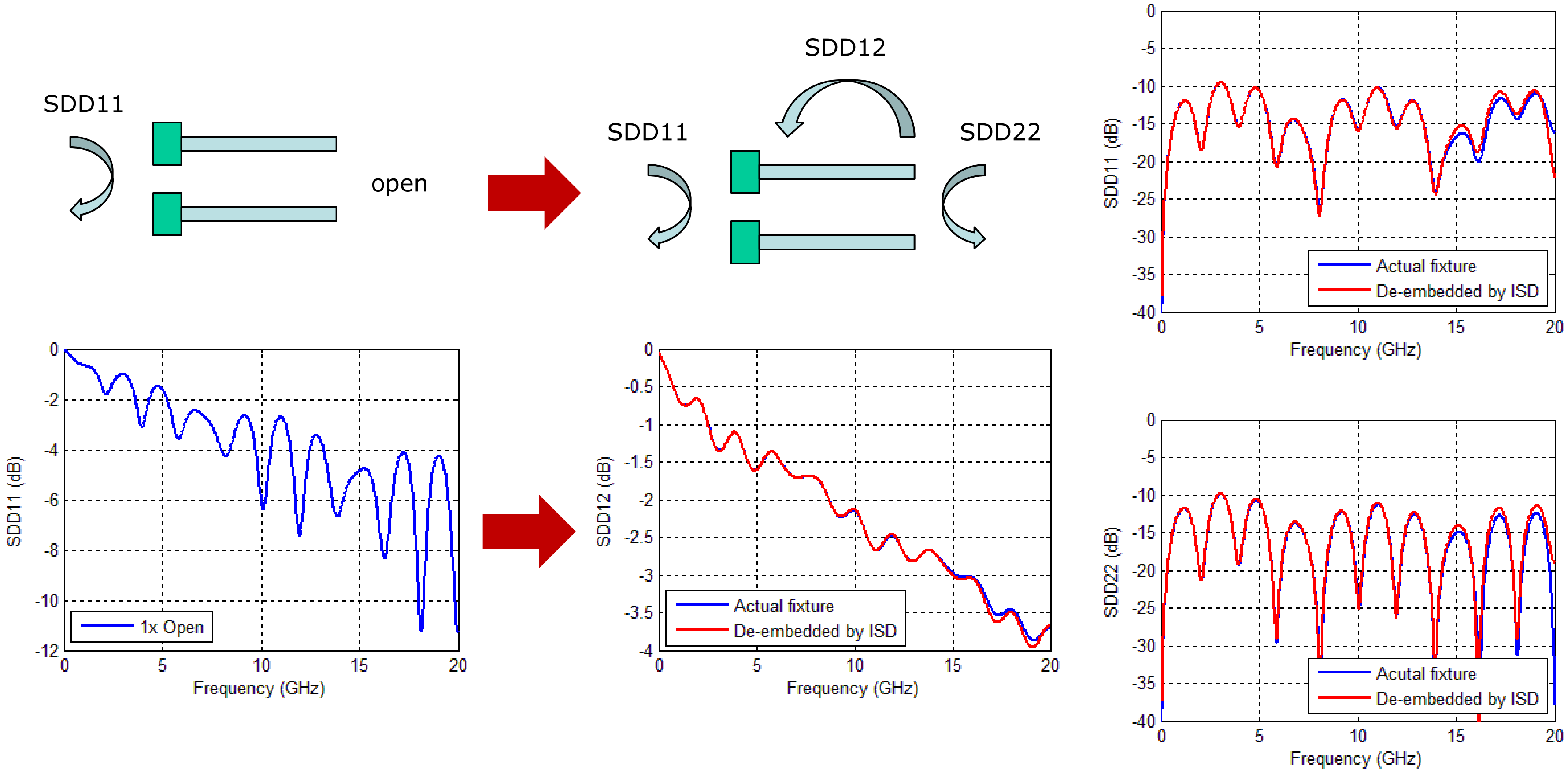
1.5″ stripline



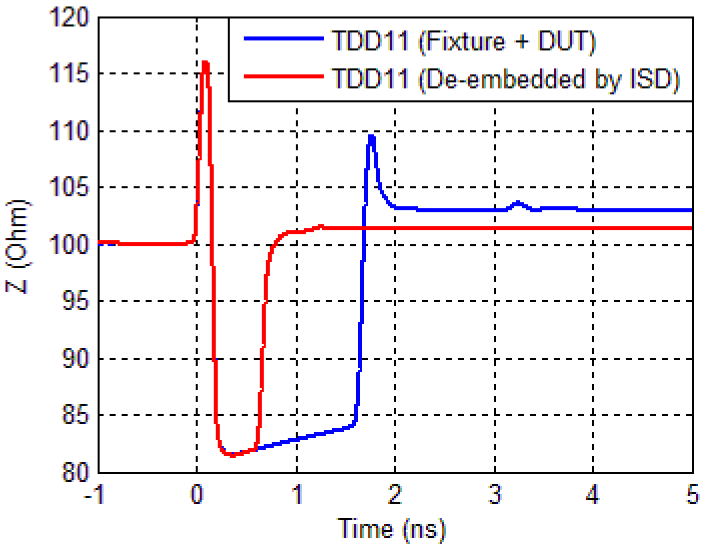


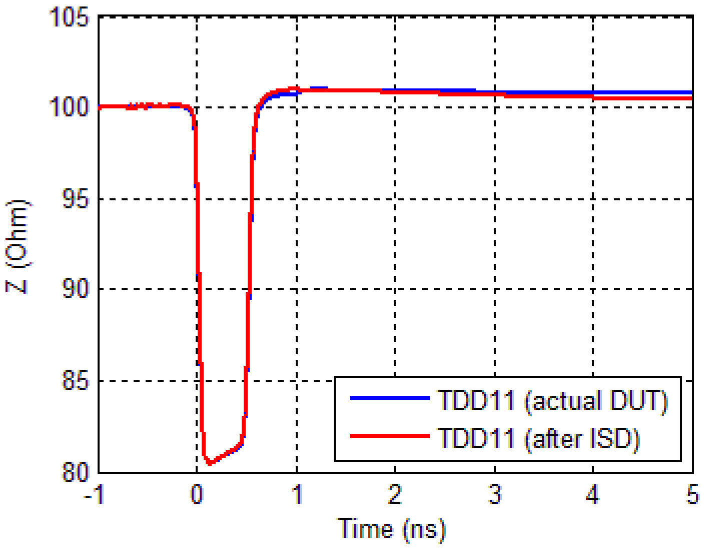


ISD can reconstruct 1x thru's IL and RL from 1x open's RL

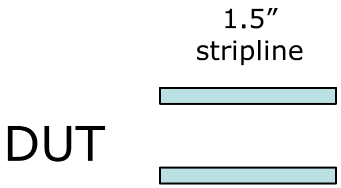


ISD’s “in-situ” technology matches the fixture’s impedance for de-embedding





IL and RL extracted by ISD match the actual values very well


1.5″
stripline

DUT